

# Infrared Variation of Blazars

J.H. Fan

Center for Astrophysics, Guangzhou Normal University, Guangzhou 510400, China, e-mail:

jhf@guangztc.edu.cn

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## ABSTRACT

In this paper, the historical infrared (JHK) data compiled from the published literature are presented here for 30 blazars. Maximum near-IR variations are found and compared with the optical ones. Relations between color index and magnitude and between color-color indices are discussed individually. For the color-magnitude relation, some objects (0215+015, 0422+004, and 1641+395) show that the color index increases with magnitude indicating that the spectrum flattens when the source brightens while 1253-055 shows complex behaviour: the spectrum steepens when the source dims in J band and the spectrum flattens when the source dims further suggesting that the emission mechanism consists of, at least, two parts in this case. From the color indexes, we have that the spectral indexes are in the range of  $\alpha_{IR} = 0.77 \sim 2.37$  ( $f_\nu \propto \nu^{-\alpha}$ ).

*Subject headings:* Variability–Infrared–Blazars

## 1. Introduction

While the nature of active galactic nuclei (AGNs) is still an open problem, the study of AGNs variability can yield valuable information about their nature. Photometric observations of AGNs are important to construct light curves and to study variability behavior over different time scales. In AGNs, some long-term optical variations have been observed and in some cases claimed to be periodic (see Fan et al. 1998a).

Blazars are AGNs characterized by compact radio core, high and variable radio and optical polarization, superluminal radio components. The continuum emissions are rapidly variable at all frequencies with amplitude and rapidity increasing with frequency ( see Kollgaard 1994 ). Blazars include BL Lac objects, optically violently variable quasars (OVVS), highly polarized quasars (HPQs), flat spectrum radio quasars (FSRQ) and core dominated quasars (CDQ). All those objects are basically the same thing (Fugmann 1989; Impey et al. 1991; Valtaoja et al. 1992; Will et al. 1992).

Before  $\gamma$ -ray observations were available, Impey & Neugebauer (1988) found that the infrared emission (1-100  $\mu m$ ) dominates the bolometric luminosities of blazars. The infrared emissions are also an important component for the luminosity even when the  $\gamma$ -ray emissions are included ( von Montigny 1995). Study of the infrared will provide much information of the emission mechanism. The long-term infrared variations have been presented for some selected blazars in a paper by Litchfield et al. (1994).

Infrared observations have been done for blazars for more than 20 years. Neugebauer et al. (1979) presented the infrared variations for a few blazars with the observation time being back to the 1960's. The infrared observations done over a period of 8 years have also been presented for some selected blazars in the paper by Litchfield et al. (1994). But there are no available long-term infrared variations in the literature for all these objects. Recently, we have obtained the long-term infrared variation for 40 radio selected BL Lac objects (Fan & Lin 1999a). In this paper, we mainly present the long-term infrared (J,H, and K bands ) light curves for some

blazars and discuss the variation properties. The compiled data available from the author (e-mail: jhfan@guangztc.edu.cn). This paper has been arranged similar to our previous paper (Fan & Lin 1999a). In section 2, we review the literature data and light curves; in section 3, we discuss the variations and give some remarks for each object, and a short summary.

## 2. Near-infrared Light Curves

### 2.1. Data from Literature

Infrared observations are available since the end of the 1960s. We compiled the data from 47 publications. They are listed in table 1 & 2, which gives the observers in Col. 1. and the telescope(s) used in Col.2. For the J, H, and K magnitudes, they are listed in an table 4 in electronic form. In table 4, Col. 1 gives the name; Col. 2. the JD time; Col. 3, the J magnitude; Col. 4 the uncertainty for J; Col. 5, the H magnitude; Col. 6, the uncertainty for H; Col. 7, K magnitude; Col. 8, the uncertainty for K.

### 2.2. Data Analysis

The flux densities from the literature had been converted back to magnitudes using the original formulae. In the literature, different telescopes are used, different telescopes use photometers with slightly different filter profiles, resulting in slightly different calibration standards and zero-points, but the uncertainty aroused by the different systems is no more than a few percent.

The magnitude is dereddened using  $A(\lambda) = A_V(0.11\lambda^{-1} + 0.65\lambda^{-3} - 0.35\lambda^{-4})$  for  $\lambda > 1\mu m$  and  $A_V = 0.165(1.192 - \tan b) \csc b$  for  $|b| \leq 50^\circ$  and  $A_V = 0.0$  for  $|b| > 50^\circ$  (Cruz-Gonzalez & Huchra 1984, hereafter CH (84); Sandage 1972; Fan et al. 1998b). It is clear that some objects have many observations while others have only a few data points, in Figures 1-15, we show only those with more observations.

For data shown in Figs. d - i of each object we have performed linear fit with uncertainties in

both coordinates considered (see Press et al. 1992 for detail),

$$y(x) = a + bx \quad (1)$$

In principle,  $a$  and  $b$  can be determined by minimizing the  $\chi^2$  merit function (i.e. equation 15.3.2 in Press et al. book)

$$\chi^2(a, b) = \sum_{i=1}^n (y_i - a - bx_i)^2 w_i \quad (2)$$

where  $\frac{1}{w_i} = \sigma_{y_i}^2 + b^2 \sigma_{x_i}^2$ ,  $\sigma_{y_i}$  and  $\sigma_{x_i}$  are the  $x$  and  $y$  standard deviations for the  $i$ th point. Unfortunately, the occurrence of  $b$  in the denominator of the above  $\chi^2$  merit function, resulting in equation  $\frac{\partial \chi^2}{\partial b} = 0$  being nonlinear makes the fit very complex, although we can get a formula for  $a$  from  $\frac{\partial \chi^2}{\partial a} = 0$ :

$$a = \frac{\sum_i w_i (y_i - bx_i)}{\sum_i w_i} \quad (3)$$

Minimizing the  $\chi^2$  merit function, equation (2), with respect to  $b$  and using the equation (3) for  $a$  at each stage to ensure that the minimum with respect to  $b$  is also minimized with respect to  $a$ , we can obtain  $a$  and  $b$ . As Press et al. stated, the linear correlation coefficient  $r$  then can be obtained by weighting the relation (14.5.1) terms of Press et al. (1992). Finding the uncertainties,  $\sigma_a$  and  $\sigma_b$ , in  $a$  and  $b$  is more complicated (see Press et al. 1992). Here, we have not performed this. For the data whose uncertainties were not given in the original literature are not included in our linear fit or in Fig. d-i, but they are included in the light curves (Fig. a - c).

As discussed in the paper of Massaro & Trevese (1996) (also see Fan & Lin 1999a), there is a statistical bias in the spectral index-flux density correlation. Following their suggestion, we considered the relation between magnitude in one band and the color index obtained from two other bands to avoid this bias. The relations are shown in Fig. d-f.

### 3. Discussion

### 3.1. Variations

Blazars are variable at all wavelengths. For blazars with enough infrared data, we presented their variability properties in Table 3, which gives the name in Col. 1, redshift in Col. 2, reddening correction,  $A_V$ , in Col. 3, largest optical polarization ( $P_{opt}$ ) in Col. 4, maximum amplitude optical variation ( $m_{opt}$ ) in Col. 5, maximum amplitude variations in J, H, and K in Col. 6, 7, and 8, the averaged color index (J-H) and (H-K) in Col. 9, and 10, the uncertainty in Col. 9 and 10 is the one sigma deviation. The infrared variations are very large for some objects. For variation, it is reasonable for larger variation to correspond to shorter wavelength, but some objects show different behaviour in the present paper. It is interesting to note that the object having steepening spectrum when the source brightens shows that the variation at the longer wavelength is larger than that at the shorter one. Most objects showing large optical variation also show large infrared variations and high polarizations, large variation and high polarization are associated. For the color-indices, we have that (J-H) covers a range of 0.66 to 1.44 suggesting a range of spectral index  $\alpha = 0.77$  to 2.37 since  $(J-H) = 0.300\alpha + 0.43$  (Sitko, private communication).

It is possible that more than one mechanism is responsible for the emission in the infrared region, i.e., it is reasonable that a nonvariable or slowly varying near-IR component, such as the stars in the parent galaxy, is present in the spectrum of AGNs. In this sense, when the source is bright, the spectrum is observed to steepen when the source dims, as expected from a synchrotron component which experiencing radiative energy losses, but when the source dims further, because of the presence of the underlying near-IR emission, the spectrum will flattens with the source getting faint (Fan 1999a,b). So, the investigation of the relation between spectrum index and flux can throw some lights on the components of near-IR emission mechanism, particularly when the source is faint. Our analysis in the present paper indicates that there are perhaps at least two components in the near-IR region of 3C 279, but it should be confirmed with more observations.

Following the variation properties are discussed for individual object.

### 3.2. Remarks

#### 3.2.1. 0109+224, $z=?$

This polarized ( $P_{opt.} = 17.26 \pm 1.63\%$ ,  $P_{IR} = 13.87 \pm 0.74\%$ , Mead et al. 1990) object shows a variation of  $\Delta B = 3.07$  (Bozayan et al. 1990). The infrared variations are less than in the optical one, no correlation is found for color index and magnitude. There is an indication of a correlation between (J-K) and (J-H), but not for other color indices (see Fig. 1).

#### 3.2.2. 0215+015, $z_{abs} = 1.686$

It is one of the most luminous ( $B = 14.5 \sim \geq 19.5$  Pettini et al. 1983) known BL Lac objects and polarized at  $P_{IR} = 17.4 \pm 1.1\%$  in H band (Holmes et al. 1984) and  $P_{opt} = 20\%$  (Angel & Stockman 1980). There are only a few infrared data in the literature, which show a positive correlation between color index and magnitude suggesting the spectrum flattens when the source brightens: (H-K) = 0.08J - 0.26 with  $r = 0.97$  and  $p = 1.2\%$ ; (J-K) = 0.16H - 0.36 with  $r = 0.89$  and  $p = 4.5\%$ . Those color-magnitude correlations were obtained based on 4 points, so they should be confirmed with more observations. For color indices, there is also an indication of correlations between (J-K) and (J-H) and (H-K) as well with  $p < 5\%$  (see Fig. 2).

#### 3.2.3. 0301-243, $z=?$

This moderately variable ( $\Delta m = 0.89$ , Pica et al. 1988) object has been observed in the infrared for 3 nights showing a variation of 0.20 mag and color indices of (J-H) =  $0.81 \pm 0.05$ , (J-K) =  $1.52 \pm 0.03$  and (H-K) =  $0.71 \pm 0.05$ . It is polarized at  $P_{opt.} = 10.97\%$  (Impey & Tapia 1988).

### 3.2.4. 0323+022, $z = 0.147$

It is one of the X-ray selected BL Lac objects (XBLs) showing extremely rapid variation. An X-ray variation over a time scale of 30 seconds was observed by Feigelson et al. (1986), who also noticed a brightness decrease of 1.3 mag within one day in the optical region. Polarizations of  $P_{opt.} \sim 2 - 9\%$  (Feigelson et al. 1986) and  $P_{IR} = 4.65 \pm 1\%$  (Mead et al. 1990) are reported. It can be obtained that the optical spectral index is strongly associated with the brightness ( $V = -(1.52 \pm 0.04)(B - V) + 17.07 \pm 0.02$ , with a correlation coefficient of  $r = -0.967$ ) when the optical observations (Feigelson et al. 1996) are taken into account. There are only a few infrared data for this object showing variations of  $\Delta J = 0.30$ ,  $\Delta H = 0.52$  and  $\Delta K = 0.96$ .

### 3.2.5. 0336-019, CTA26, $z = 0.852$

There are only 4 nights of infrared data for this polarized ( $P_{opt} = 19.4\%$ , Impey & Tapia 1990) and variable ( $\Delta m = 1.4$ , Pica et al. 1988) object showing  $J = 15.45$ ,  $H = 15.00-15.96$ , and  $K = 14.57-15.99$  and color indices of  $(J-H) = 0.45 \pm 0.32$ ,  $(J-K) = 0.88 \pm 0.29$ , and  $(H-K) = 0.43 \pm 0.25$ .

### 3.2.6. 0406+121, $z = 1.02$

There are only 6 nights of infrared data for this faint ( $V = 20.4$ , Rieke et al. 1979) object showing variations of  $\Delta H = 0.90$ , and  $\Delta K = 1.78$  and color indices of  $(J-H) = 1.13 \pm 0.07$ ,  $(J-K) = 2.11 \pm 0.07$  and  $(H-K) = 0.98 \pm 0.07$ .

### 3.2.7. 0420-014, OA129, $z = 0.915$

The infrared data show variations of  $\Delta J = 2.46$ ,  $\Delta H = 2.88$  and  $\Delta K = 2.61$  and color indices of  $(J-H) = 0.80 \pm 0.16$ ,  $(J-K) = 1.65 \pm 0.10$ , and  $(H-K) = 0.86 \pm 0.16$ . A polarization of  $P_{opt} = 20.19 \pm 1.26\%$  and an optical variation of  $\Delta m = 2.8$  are reported in the paper of Angel &



Stockman (1980). In addition, the optical polarization is wavelength-dependent with polarization being higher at longer wavelength (Smith et al. 1988). The limited data indicate that K is anti-correlated with (J-H), but this kind of correlation is far from certainty.

### 3.2.8. 0422+004, $z=?$

An optical variation of  $\Delta m = 2.2$  (Branly et al. 1996) and high and variable polarizations are known for this object. The infrared polarization increases from 13.6% to 19.8% when the source dimmed by 0.3 mag in K (Holmes et al. 1984) and in other case it decreases from 20.27% to 12.25% in two days when the source does not show significant variation, during which period the optical polarization also decreases from 22.14% to 13.69% (Mead et al; 1990). The infrared data show that the infrared variations are similar to the optical ones. A correlation between (H-K) and J:  $(H-K) = -0.51 + 0.1J$  with  $r = 0.50$  and  $p = 4.4 \times 10^{-3}$ . There are close correlations between (J-K) and (J-H) and (H-K):  $(J-K) = 0.17 + 1.80(J-H)$  with  $r = 0.81$  and  $p = 5.4 \times 10^{-8}$ ;  $(J-K) = 0.19 + 1.76(H-K)$  with  $r = 0.789$  and  $p = 2.8 \times 10^{-7}$  (see Fig. 3).

### 3.2.9. 0521-365, $z = 0.055$

This steep-spectrum radio source was identified with an N galaxy by Bolton et al. (1965b), a redshift of  $z_{em} = z_{abs} = 0.055$  was shown by Danziger et al. (1978). A Polarization of  $P_{opt} \sim 11\%$  (Bailey et al. 1983) and a variation of  $\Delta m = 1.4$  (Angel & Stockman, 1980) are reported. The infrared data show correlations between (J-K) and (J-H) and (H-K) (see Fig. 4).  $(J-K) = 0.36 + 1.40(J-H)$  with  $r = 0.89$  and  $p = 2.4 \times 10^{-4}$ ;  $(J-K) = -0.32 + 2.62(H-K)$  with  $r = 0.756$  and  $p = 5.0 \times 10^{-3}$ . The infrared variation in K is similar to that in the optical band.

3.2.10. 0548-322,  $z = 0.069$

The radio source was found and identified with a 15 mag galaxy, photometry yield  $V=15.5\pm0.1$ ,  $(B-V) = 0.57\pm0.02$ , and  $(U-B) = -0.30\pm0.03$  (see Disney 1974). The infrared data indicate that the variation in K is larger than those in J and H, the color indices show an anti-correlation between (J-H) and (H-K):  $(H-K) = 1.12 - 0.94(J-H)$  with  $r = -0.76$  and  $p = 2.67\%$  (see Fig. 5)

3.2.11. 0716+322,  $z = ?$

The 4 nights of infrared data show variations of  $\Delta J = 2.06$ ,  $\Delta H = 2.05$  and  $\Delta K = 2.51$  and color indices of  $(J-H) = 0.73\pm0.04$ ,  $(J-K) = 1.50\pm0.02$  and  $(H-K) = 0.84\pm0.12$ .  $P_{opt} = 7.43\pm0.56\%$  and a wavelength-dependence of  $P$ ,  $dP/d\lambda < 0$  are observed by Smith et al.(1988).

3.2.12. 0736+017,  $OI + 061$ ,  $z = 0.191$

This nearby quasar has shown a variation of  $\Delta m = 1.35$  (Pica et al. 1988). The optical polarization ( $P_{opt} = 0\% - 6\%$ ) is less than the infrared one ( $P_{IR} = 7.3 \pm 4.3\%$ , Holmes et al. 1984). The infrared light curves show that the source has been brightening with time, but some brightness fluctuations also show up. (J-K) is found to be correlated with (J-H) and (H-K):  $(J-K) = 0.36 + 1.64(J-H)$  with  $r = 0.83$  and  $p = 1.2 \times 10^{-3}$   $(J-K) = -0.11 + 2.04(H-K)$  with  $r = 0.73$  and  $p = 7.0 \times 10^{-3}$ . Complex associations can be seen for color index and magnitude in Fig. 6,e,f (see Fig. 6).

3.2.13. 0823-223,  $z > 0.91$

This polarized ( $P_{opt} = 4\% - 10.75\%$ , Impey & Tapia 1988) object has shown an optical variation of  $\Delta V = 1.5$  and  $(V-K) = 3.7$ . The optical spectrum steepens when the source brightens

( $\alpha_{opt} = 1.7 \pm 0.02$  when  $V=15.7$ , and  $\alpha_{opt} = 2.1 \pm 0.1$  when  $V=16.6$ , Falomo 1990). It has been observed in the infrared on some occasions, the data show an indication of an anti-correlation between color index and magnitude, which is different from the optical behaviour:  $(J-H) = 3.19 - 0.20K$  with  $r = -0.87$  and  $p = 1.2\%$ . For the color indices,  $(J-K)$  is correlated with  $(J-H)$  and  $(H-K)$  (see Fig. 7).

#### 3.2.14. 0912+297, OK222, $z=?$

There are only 6 nights of infrared data for this polarized ( $P_{IR} = 13.5 \sim 2.8\%$ , Holmes et al. 1984,  $P_{opt} = 13\%$ , Angel & Stockman 1980) object showing variations of  $\Delta H = 2.27$ , and  $\Delta K = 2.41$  and color indices of  $(J-H) = 0.71 \pm 0.08$ ,  $(J-K) = 1.53 \pm 0.11$  and  $(H-K) = 0.85 \pm 0.20$ . The optical variation ( $\Delta m = 2.25$ , Bozayan et al. 1990) is similar to in the infrared one.

#### 3.2.15. 1034-293, $z = 0.311$

It is polarized at  $P_{opt} = 13.8 \pm 1.18\%$  (Wills et al. 1992). The limited infrared data give a variation of 1 mag in K and color indices of  $(J-H) = 1.00 \pm 0.05$ ,  $(J-K) = 1.95 \pm 0.15$ , and  $(H-K) = 0.95 \pm 0.20$ .

#### 3.2.16. 1055+018, $z = 0.888$

There are only two nights of infrared data for this polarized ( $P_{opt} = 6\%$ , Impey & Tapia 1988) object showing a variation of  $\Delta H = 0.54$  and color indices of  $(J-H) = 0.66 \pm 0.14$ ,  $(J-K) = 1.82 \pm 0.15$ , and  $(H-K) = 1.16 \pm 0.13$ .

*3.2.17. 1156+295, 4C29.45, Ton599,  $z = 0.728$*

This variable ( $\Delta m = 5.0$ , Branly et al. 1996) object shows high and variable polarizations ( $P_{IR} = 28.06\%$ ,  $P_{opt}=28\%$ , Holmes et al. 1984; Mead et al. 1990). The optical polarization increase from 5% to 20% between 1984 June 9 and 10 (Smith 1996). During the simultaneous observations, 1156+295 did not show significant change in the shape of the IR-UV spectrum when the flux varied (Glassgold et al. 1983). The infrared light curves show two double-peaked outbursts. There are positive correlations between (J-K) and (J-H) as well as (H-K), but the association between color index and magnitude is complex, no definite correlation can be obtained (see Fig. 8), which is similar to the result found in the optical band by Glassgold et al (1983)(also See Fan 1999b).

*3.2.18. 1218+304, RS4,  $z = 0.130$*

The X-ray source is one of the best observed in the “2A” catalogue of high galactic-latitude sources (Cooke et al. 1978; Wilson et al. 1979). An optical polarization of  $P_{opt} = 6.6\%$  is known (Wills et al. 1992). There are 4 nights of infrared data showing a variation of  $\Delta K = 0.91$  and color indices of (J-H) =  $0.67 \pm 0.10$ , (J-K) =  $1.50 \pm 0.29$ , and (H-K) =  $0.78 \pm 0.16$ .

*3.2.19. 1244-255,  $z = 0.638$*

There are only 3 nights of data showing a variation of  $\Delta H = \Delta K = 0.95$  and color indices of (J-H) =  $0.86 \pm 0.25$ , (J-K) =  $1.69 \pm 0.22$ , and (H-K) =  $0.82 \pm 0.27$ . An optical polarization of  $P_{opt} = 8\% - 12\%$  (Impey & Tapia 1988) and a variation of  $\Delta V = 2.0$  (Bozayan et al. 1990) are reported.

3.2.20. 1253-055, 3C279,  $z = 0.536$

3C279 is a well known member of OVVs, a large optical variation of  $\Delta B \geq 6.70$  mag (Eachus & Liller 1975) and a highly optical polarization of  $P_{opt} = 44\%$  ( see Fan et al. 1996) and a possible variability period of 7-year (Fan 1999) are reported. It is the prototype of superluminal radio sources and shows a violently optical brightness increase of 2.0 mag during an interval of 24 hours (Webb et al. 1990). The infrared light curves show 3 outbursts. The (J-K) is strongly associated with (J-H) and (H-K). There is a positive correlation between color index and magnitude ( see Fig. 9). For (H-K) and J, there is a positive correlation between them when J is brighter than 14 magnitude but there is a negative correlation between them when the source is fainter than 14 magnitude. From above discussion, it is possible that the emission mechanism consists of two components in the case ( also see Fan 1999a,b).

3.2.21. 1510-089,  $z = 0.361$

1510-089 is one of the largest variable objects with  $\Delta B = 5.4(11.8 - 17.2)$  (Bozayan et al. 1990). A maximum optical polarization of  $P_{opt} = 14.45\%$  is reported and the optical polarization is found to be wavelength-dependent with  $dP/\lambda > 0$  (see Smith et al. 1988), the infrared polarization is  $P_{IR} = 9.07\%$  (Mead et al. 1990). The infrared light curves show a clear brightness increase with the variation in the shorter wavelength being smaller than that in the longer one. (J-K) is correlated with (H-K), no correlated between color index and magnitude can be found from the available data (see Fig. 10).

3.2.22. 1641+395, 3C345,  $z = 0.595$

3C345 is one of the well studied quasars (Bregman et al. 1986a; Smith 1996, and references therein), it gives us a well-documented example of a clear connection between brightness and polarization as well as polarization angle (Smith 1996). It is polarized at  $P_{IR} = 0\% - 20.27\%$

(Mead et al. 1990) and  $P_{opt} = 5\% - 35\%$  (Bregman et al. 1986a). The optical variation of  $\Delta m = 2.5$  (Bregman et al, 1996a) is smaller than that in the infrared variation of  $\Delta J = 3.16$  mag. The infrared observations in the paper of Bregman et al (1986a) are also included in our discussion although the paper is not listed in table 1 for they have not indicated their telescopes used. The infrared light curves show clearly two outbursts separating by about 11.3 years which is consistent with the 11.4-year optical outburst period ( Webb et al. 1988, also see Fan et al. 1998a for summary). For the color indices, (J-K) is found correlated strongly with (J-H) and (H-K). A correlation is found between color index and magnitude (see Fig. 11): (J-K) =  $0.49 + 0.10H$  with  $r = 0.555$  and  $p = 7.6 \times 10^{-6}$ , (J-K) =  $0.27 + 1.76 (J-H)$  with  $r = 0.80$  and  $p = 6.6 \times 10^{-14}$ , (J-K) =  $0.003 + 1.93 (H-K)$  with  $r = 0.82$  and  $p = 1.0 \times 10^{-14}$ .

### 3.2.23. 1717+177, OT129, $z=?$

It is identified by Hoskins et al. (1974) and Condon et al. (1977) with a starlike object of 18.5 mag (also see Veron & Veron, 1993). There are only 4 nights of infrared data for this polarized ( $P_{opt.} = 27\%$ , Angel & Stockman 1980;  $P_{IR} = 16.85\%$ , Mead et al. 1990) object showing a variation of  $\Delta K = 1.89$  and color indices of (J-H) =  $0.92 \pm 0.03$ , (J-K) =  $1.90 \pm 0.03$ , and (H-K) =  $0.98 \pm 0.03$ .

### 3.2.24. 1722+119, $z=?$

This object is very interesting, its polarizations ( $P_{opt} = 17.6 \pm 1.0\%$  and  $P_{IR} = 11.9 \pm 1.1\%$ ) are at a typical level of a radio selected BL Lac object (RBL) and are strongly wavelength-dependent ( $dP/d\lambda = -5.7 \pm 1.2\%$ ), the X-ray to optical luminosity ratio is comparatively much higher and is similar to the values among XBLs (Brissenden et al. 1990). The 4 nights of data show a variation of 1.0 mag in J, H, and K and color indices of (J-H)= $0.71 \pm 0.07$ , (J-K)= $1.38 \pm 0.06$ , and (H-K)= $0.67 \pm 0.04$ .

*3.2.25. 1921-293, OV – 236,  $z = 0.352$*

An optical variation of  $\Delta m = 2.64$  (Pica et al. 1988) and polarizations of  $P_{opt.} = 16.89\%$  and  $P_{IR} = 13.94\%$  (Mead et al. 1990) are reported for this object. The H light curve shows a sharp brightness decrease, which leads H variation to be greater than the optical variation. During the sharp decreasing period, there were no observations for J or K. (J-K) is found correlated with (J-H) and (H-K) (see Fig. 12):  $(J-K) = 0.63 + 1.30 (J-H)$  with  $r = 0.80$  and  $p = 9.1 \times 10^{-4}$ ,  $(J-K) = 0.17 + 1.80 (H-K)$  with  $r = 0.50$  and  $p = 4.7\%$ .

*3.2.26. 2155-304,  $z = 0.117$*

It is the brightest XBL in the UV. The X-ray, UV, and optical light curves are well-correlated, suggesting a common origin of the optical through X-ray emissions, and the X-rays lead the UV by  $\sim 2$ -3 hours (Edelson et al. 1995). It has been extensively studied in the UV and X-rays (Pesce et al. 1996; Pian et al. 1996, and reference therein). Polarizations of  $P_{opt} = 14.2\%$  (Pesce et al. 1996) and  $P_{IR} = 9.4 \pm 0.7\%$  (Mead et al. 1990) and an optical variation of  $\Delta m_V = 1.85$  (Fan & Lin 1999b) are reported. There is an indication for (J-K) to be correlated with (J-H) and (H-K) and H as well (see Fig. 13):  $(J-K) = 1.04 - 0.04H$  with  $r = -0.37$  and  $p = 1.9\%$ .

*3.2.27. 2208-137,  $z = 0.392$*

The blazar is unusually showing symmetric double radio lobes (Antonucci & Ulvestad 1984). The double-lobed blazars are important in establishing a kinship between blazars and normal double radio sources (Antonucci et al. 1987). The 7 nights of infrared data show a moderate variation of 0.3 mag in the infrared and color indices of  $(J-H) = 0.98 \pm 0.14$ ,  $(J-K) = 2.10 \pm 0.14$ , and  $(H-K) = 1.11 \pm 0.01$ . Polarizations of  $P_{IR} = 9.32\%$  (Mead et al. 1990) and  $P_{opt} = 8.71 \pm 0.38\%$  (Moore & Stockman 1981) are known.

3.2.28. 2223-052, 3C446, ( $z_{em}=1.404$ )

The flat spectrum radio source is the prototype of the class of violently variable quasars (Bregman et al. 1986b). During the optical outbursts, the spectral index shows complex dependence on the brightness, sometimes the slope of the optical continuous is steeper (Sandage et al. 1966 ) and sometimes flatter (Visvanathan 1973) than during quiescent states. On occasions, week emission lines have been observed in the optical region, the intensities of which do not change with the spectral flux (Sandage et al 1966, see also Garilli & Tagliferri 1986). Polarizations of  $P_{opt} = 4 \sim 17.3\%$  (Impey & Tapia 1990),  $P_{IR} = 16\%$  (Impey et al. 1982) and  $P_{10\ GHz} = 4\%$  (Mead et al. 1990) and an optical variation of  $\Delta m = 5.0$  (Branly et al. 1996) are reported. The infrared light curves shows a clear outburst, after which the brightness decrease rapidly by about 4 mag in H. (J-K) is found correlated with (J-H) and (H-K), but the correlation between color index and magnitude is complex: There is a positive connection between (H-K) and J but a negative correlation between (J-H) and K (see Fig. 14):  $(H-K) = 0.06 + 0.06J$  with  $r = 0.589$  and  $p = 3.8 \times 10^{-4}$ ,  $(J-H) = 1.19 - 0.02K$  with  $r = -0.35$  and  $p = 3\%$ .

3.2.29. 2251+158, 3C454.3,  $z = 0.859$

A polarization of  $P_{opt} = 0\% - 16.0\%$  and  $\Delta m = 2.3$  are reported in the paper of Angel & Stockman (1980). A variability of 0.5 mag over a time scale of one day has also been observed in this object (Lloyd, 1984). Smith et al (1988) observed this object on 1986 Dec. 23, 1987 June 23 and 24 and found the optical polarization is less than 6% and the polarization is wavelength-dependent with  $dP/d\lambda > 0$ . The light curve indicates a variation of 1.57 mag in K which is smaller than in the optical one. (J-K) is found to be correlated with (J-H) and (H-K) (see Fig. 15):  $(J-K) = 0.48 + 1.52 (J-H)$  with  $r = 0.94$  and  $p = 1 \times 10^{-4}$ ,  $(J-K) = -0.44 + 2.36 (H-K)$  with  $r = 0.86$  and  $p = 2.3 \times 10^{-3}$ .



3.2.30. 2345-167,  $z = 0.576$

Smith et al.(1988) found that the optical polarization ( $P_B = 4.78\%$ ,  $P_R = 11.81\%$ , and  $P_I = 11.90\%$ ) wavelength-dependent. The maximum optical polarization  $P_{opt} = 3 \sim 19\%$  (Angel & Stockman 1980) and maximum optical variation of  $\Delta m = 2.55$  (Bozayan et al. 1990) are reported. There are only two nights of infrared observations showing  $J = 16.54$ ,  $H = 15.61-15.85$  and  $K = 14.58$  and color indices of  $(J-H) = 0.93 \pm 0.22$ ,  $(J-K) = 1.96 \pm 0.25$  and  $(H-K) = 1.03 \pm 0.21$ .

### 3.3. Summary

In this paper, the infrared variations are presented for 30 blazars, the light curves are shown in Fig. 1 to 15 for 15 objects with enough observations. The amplitude variation in the optical and infrared bands are compared. For the color-magnitude relation, some objects (0215+015, 0422+004, and 1641+395) show a color index increasing with magnitude, indicating that the spectrum flattens when the source brightens while 3C 279 shows a complex correlation between  $(H-K)$  and  $J$  meaning that the emission mechanism consists of two components, the rest objects do not show any clear tendency between color index and magnitude. The color indexes suggest that the spectral indexes are in the range of  $\alpha_{IR} = 0.77$  to  $2.37$ .

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Table 1: Literature and telescopes for the data

Observer(s)	Telescope(s)
Allen(1976)	UM/UCSD 1.5m
Allen et al (1982)	A-A 3.9m; UKIRT 3.8m
Bersonelli et al (1992)	ESO 3.6m & 2.2m
Brindle et al (1986)	UKIRT 3.8m
Brissenden et al(1990)	AUN 2.3m
Brown et al (1989)	UKIRT 3.8m
Cruz-Gonzales & Huchra (1984)	CTIO 4m KPNO 1.5m
Cutri et al(1985)	UOA 1.55m
Falomo et al (1993)	ESO 2.2m
Falomo (1990)	ESO 2.2m
Garcia-Lario et al(1989)	TCS 1.5m
Gear (1993)	UKIRT 3.8m
Gear et al (1985,1986)	UKIRT 3.8m
Glass (1981)	Sutherland 1.88m
Glassgold et al(1983)	UKIRT 3.8m Palomer Mt. 5m
Holmes et al (1984)	UKIRT 3.8m
Impey et al (1982,1984)	UKIRT 3.8m
Kidger & Allan (1988)	TCS 1.5m
Kidger & Casares (1989)	TCS 1.5m
Kidger et al(1992)	TCS 1.5m
Kidger et al (1993)	TCS 1.5m
Kitilainen et al (1992)	UKIRT 4m



Table 2: Literature and telescopes for the data

Observer(s)	Telescope(s)
Landau et al (1986)	UKIRT 3.8m; Hale 5m & Mount Lemnon 1.5m
Ledden et al(1981)	UM/UCSD 1.5m
Lepine et al(1985)	ESO 3.6m
Litchfield et al (1994)	ESO 2.2m
Maraschi et al(1994)	Sutherland 1.9m
Massaro et al (1995)	TIGRO 1.5m & ESO 1.0m
Mead et al (1990)	UKIRT 3.8m
Neugebauer et al(1979)	Hale 5.0m
O’Dell et al (1978)	UM/UCSD 1.5m
Puschell & Stein (1980)	UM/UCSD 1.5m
Rieke et al (1977,1979)	UOA 90inch & 61 inch
Robson et al(1983)	UKIRT 3.8m
Robson et al(1988)	UKIRT 3.8m
Roelling et al (1986)	UKIRT 3.8m
Sitko et al (1982,1983)	UM/UCSD 1.5m
Sitko & Sitko (1991)	KPNO 1.3m & 1.5m
Smith et al (1987)	KPNO 2.1m
Takalo et al(1992)	TCS 1.5m
Tanzi et al (1989)	ESO 1.5m & 3.6m
Worrall et al (1986)	MU/UCSD 1.5m

Table 3: Observed Largest Variations of Blazars

Name	z	$A_V$	$P_{opt}(\%)$	$\Delta m_{opt}$	$\Delta J$	$\Delta H$	$\Delta K$	(J-H)	(H-K)
0109+244	—	0.09	17.3	3.07	1.55	1.56	1.58	$0.80 \pm 0.22$	$0.87 \pm 0.11$
0215+015	1.715	0.0	20.	5.0	2.00	2.69	2.52	$0.83 \pm 0.05$	$0.81 \pm 0.09$
0323+022	0.147	0.068	9.	1.3	0.30	0.52	0.97	$0.73 \pm 0.10$	$0.48 \pm 0.10$
0420-014	0.915	0.163	20.	2.8	2.46	2.88	2.61	$0.80 \pm 0.16$	$0.86 \pm 0.16$
0422+004	—	0.20	22.	2.2	1.69	3.25	3.41	$0.82 \pm 0.11$	$0.82 \pm 0.07$
0521-365	0.055	0.176	11.	1.4	0.74	0.89	1.25	$0.80 \pm 0.16$	$0.69 \pm 0.21$
0548-322	0.069	0.283			0.40	0.32	0.55	$0.71 \pm 0.09$	$0.45 \pm 0.09$
0716+332	—	0.405	7.4		2.06	2.05	2.01	$0.73 \pm 0.04$	$0.84 \pm 0.12$
0736+017	0.191	0.863	6.	1.35	2.28	2.07	2.71	$0.81 \pm 0.14$	$0.88 \pm 0.13$
0823-223	0.91	0.60	11.	1.5	1.93	2.26	2.32	$0.66 \pm 0.13$	$0.65 \pm 0.13$
0912+297	—	0.05	13.	2.25	0.40	2.27	2.41	$0.71 \pm 0.08$	$0.85 \pm 0.20$
1156+295	0.728	0.0	28.	5.	4.47	3.82	3.97	$0.84 \pm 0.09$	$0.91 \pm 0.09$
1253-055	0.536	0.0	44.	6.7	4.57	4.26	4.45	$0.93 \pm 0.12$	$0.95 \pm 0.09$
1641+395	0.595	0.09	35.	2.5	3.16	3.13	3.15	$0.87 \pm 0.14$	$0.95 \pm 0.10$
1510-089	0.360	0.10	14.	5.4	0.88	0.97	1.25	$1.14 \pm 0.05$	$1.08 \pm 0.09$
1921-293	0.352	0.47	17.	2.64	2.10	3.04	2.16	$0.92 \pm 0.08$	$0.90 \pm 0.09$
2155-304	0.117	0.0	14.2	1.85	1.26	1.88	1.24	$0.66 \pm 0.09$	$0.62 \pm 0.07$
2223-052	1.404	0.01	17.3	5.0	3.84	3.96	3.77	$0.93 \pm 0.11$	$0.92 \pm 0.17$
2251+158	0.859	0.10	19.	2.5	0.76	1.31	1.57	$0.68 \pm 0.11$	$0.84 \pm 0.09$

### Figure Captions

Fig. 1. Light curves and color index properties for 0109+224. *a*: J light curve; *b*: H light curve; *c*: K light curve; *d*: (J-H) vs. K; *e*: J-K vs. K; *f*: (H-K) vs K; *g*: (H-K) vs. (J-H); *h*: J-K vs. (J-H); *i*: J-K vs. (H-K)

Fig. 2. Light curves and color index properties for 0215+015

Fig. 3. Light curves and color index properties for 0422+004

Fig. 4. Light curves and color index properties for 0521-365

Fig. 5. Light curves and color index properties for 0548-322

Fig. 6. Light curves and color index properties for 0736+017

Fig. 7. Light curves and color index properties for 0823-223

Fig. 8. Light curves and color index properties for 1156+295

Fig. 9. Light curves and color index properties for 1253-055

Fig. 10. Light curves and color index properties for 1510-089

Fig. 11. Light curves and color index properties for 1641+395

Fig. 12. Light curves and color index properties for 1921-293

Fig. 13. Light curves and color index properties for 2155-304

Fig. 14. Light curves and color index properties for 2223-052

Fig. 15. Light curves and color index properties for 2251+158

Table 4: Near-Infrared Observations of 40 Radio-Selected BL Lac Objects

Name	JD 2400000+	J	$\sigma$ J	H	$\sigma$ H	K	$\sigma$ K
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

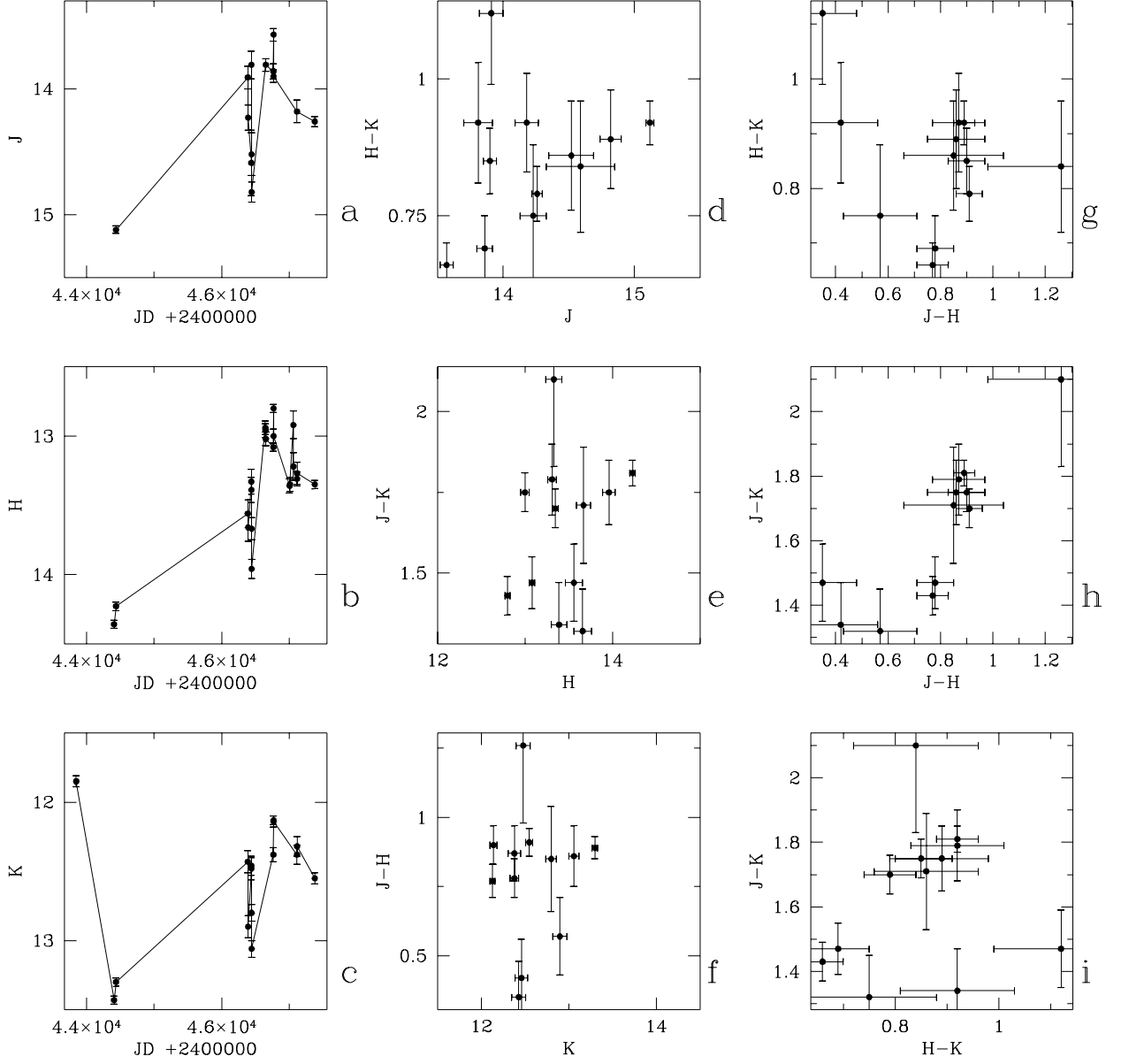


Fig. 1.— Light curves and color index properties for 0109+224. *a*: J light curve; *b*: H light curve; *c*: K light curve; *d*: (J-H) vs. K; *e*: (J-K) vs. K; *f*: (H-K) vs. K; *g*: (H-K) vs. (J-H); *h*: (J-K) vs. (J-H); *i*: (J-K) vs. (H-K)

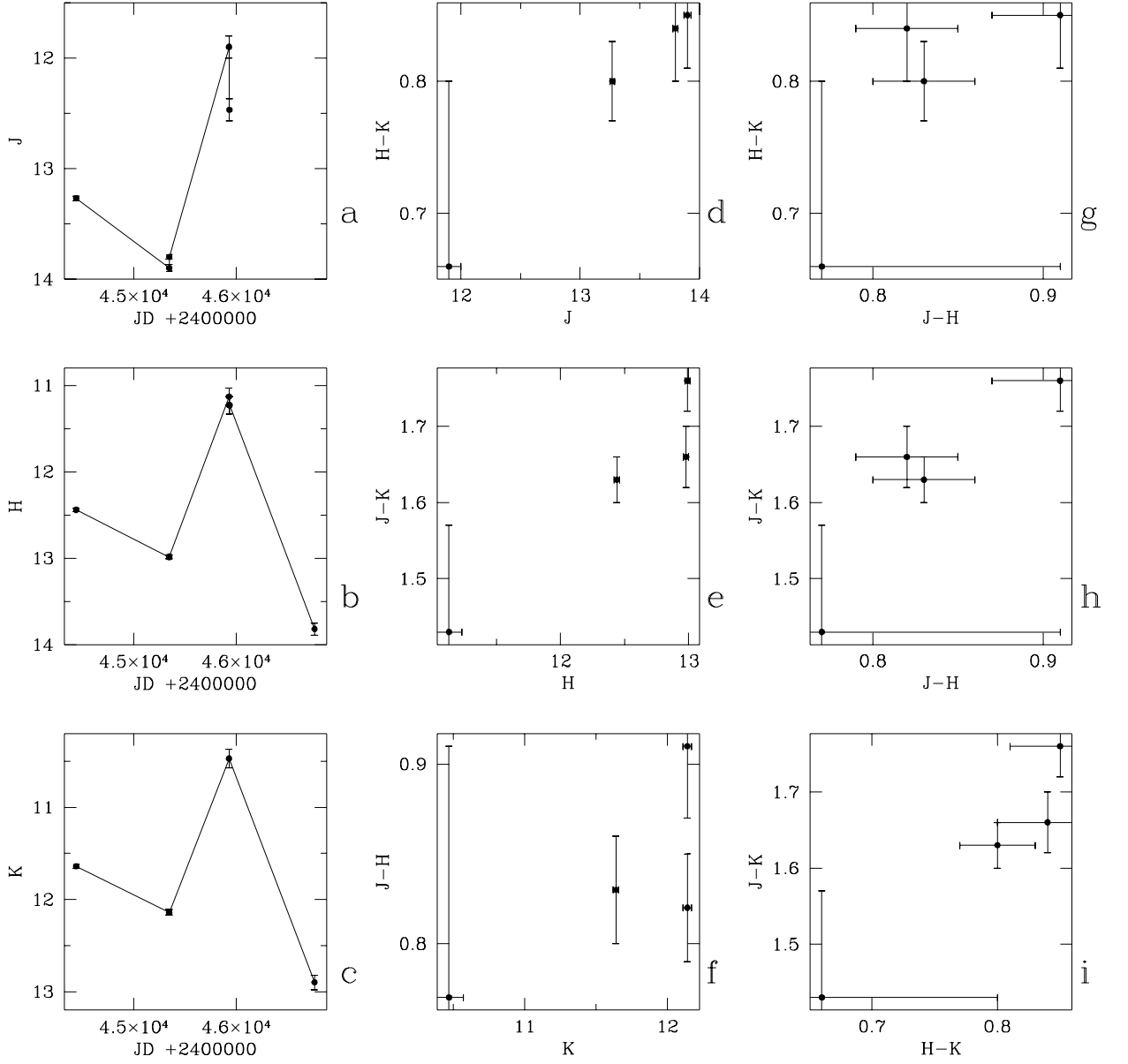


Fig. 2.— Light curves and color index properties for 0215+015.

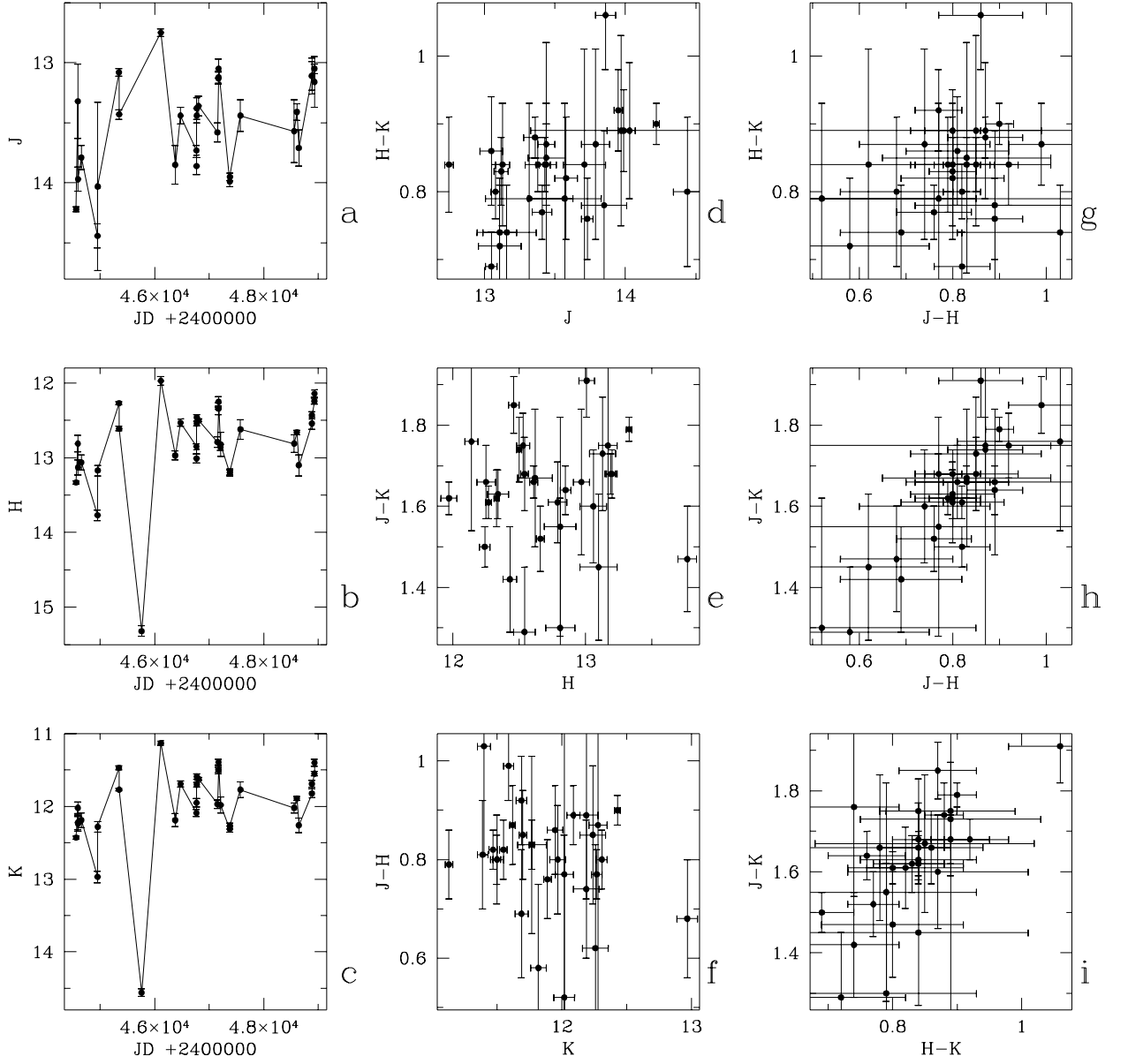


Fig. 3.— Light curves and color index properties for 0422+004

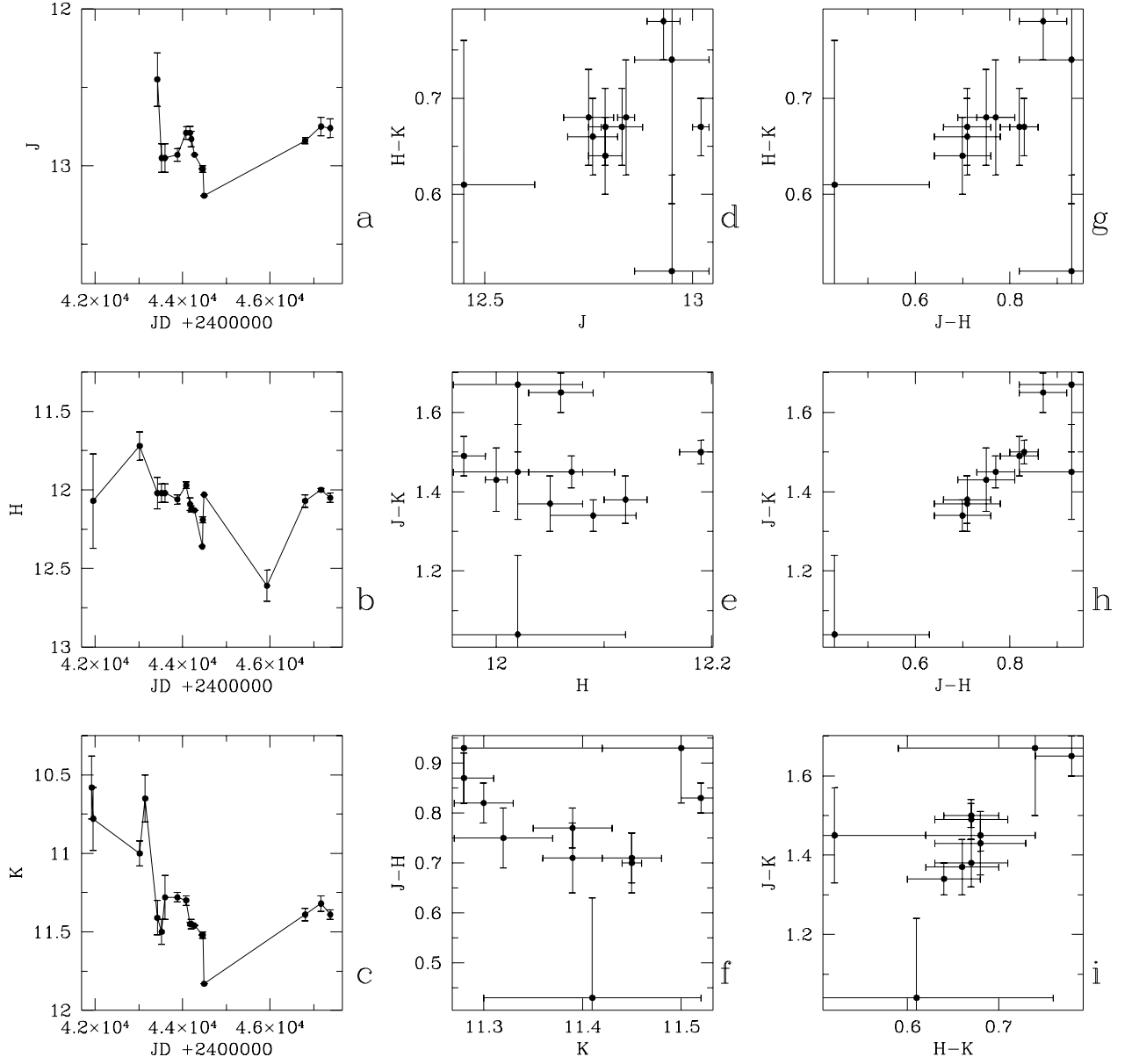


Fig. 4.— Light curves and color index properties for 0521-365

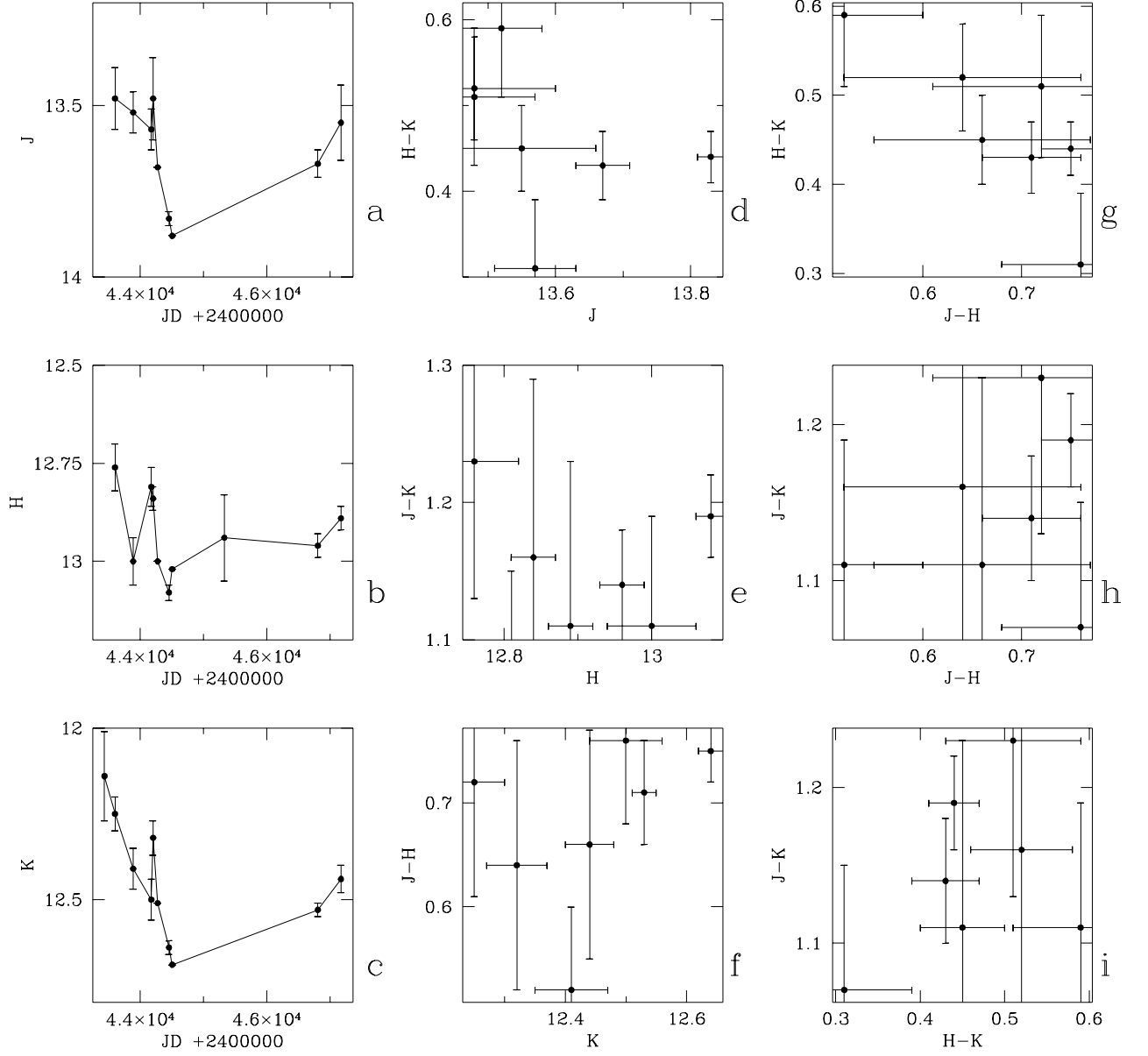


Fig. 5.— Light curves and color index properties for 0548-322



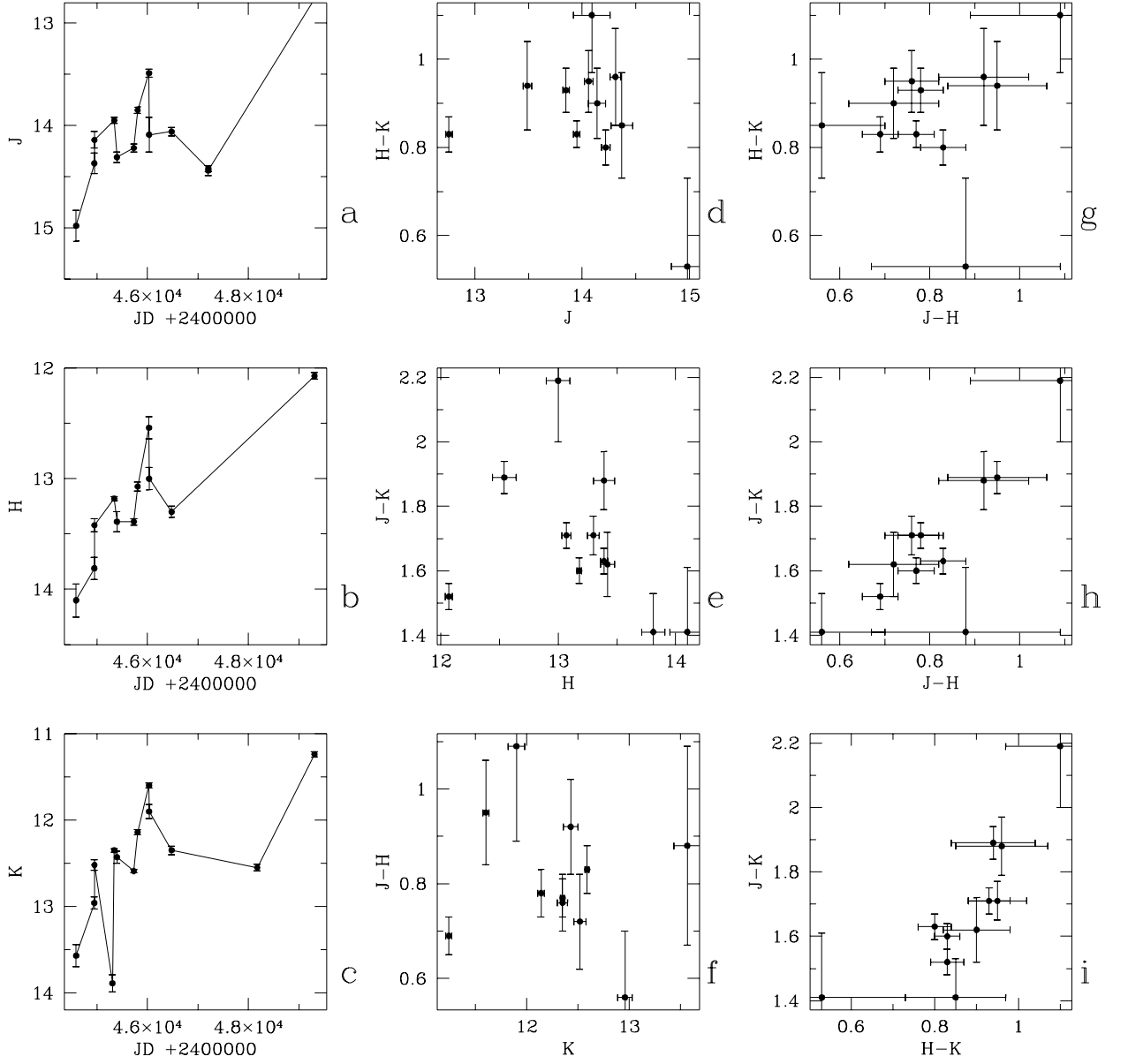


Fig. 6.— Light curves and color index properties for 0736+017

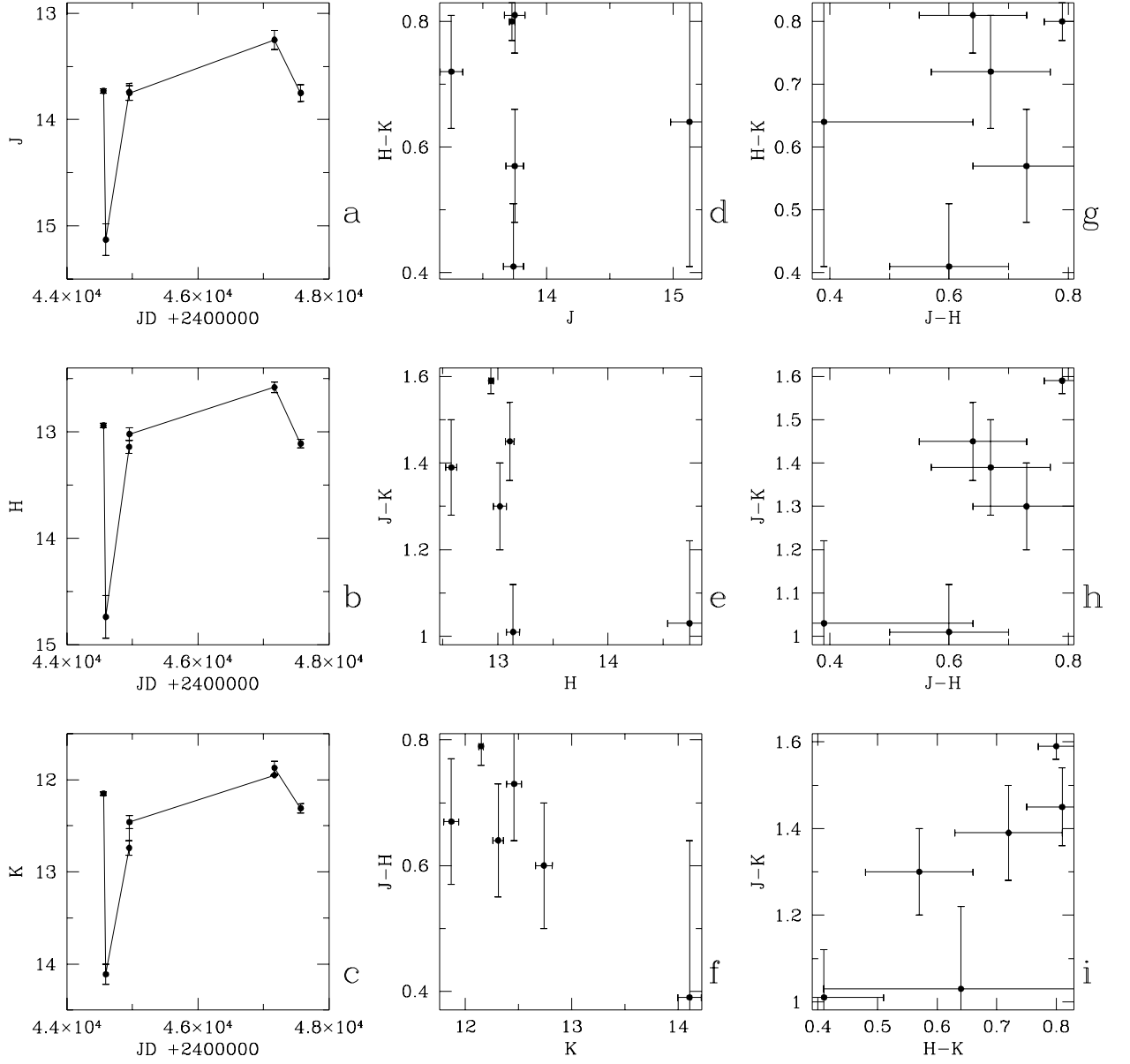


Fig. 7.— Light curves and color index properties for 0823-223

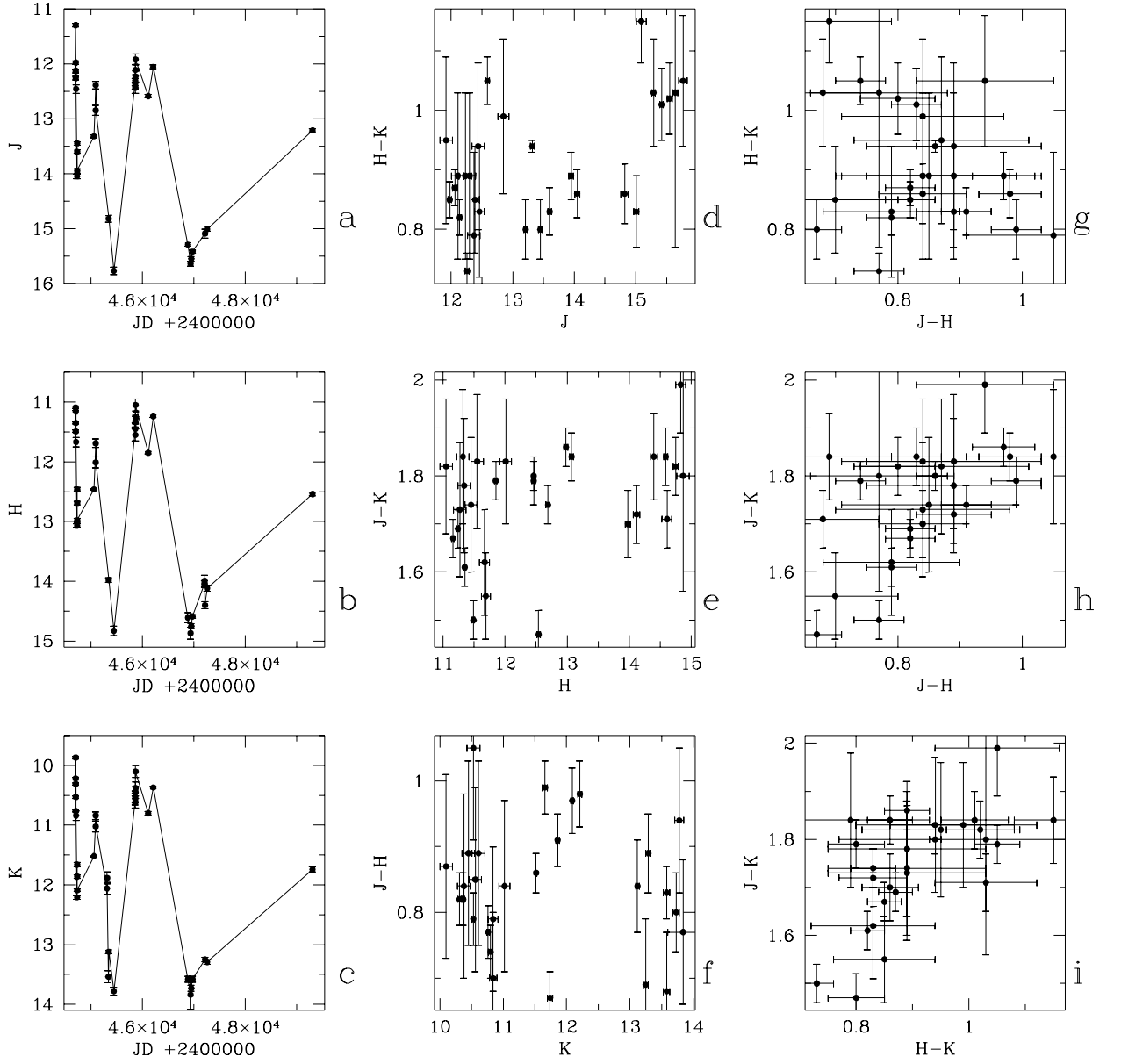


Fig. 8.— Light curves and color index properties for 1156+295

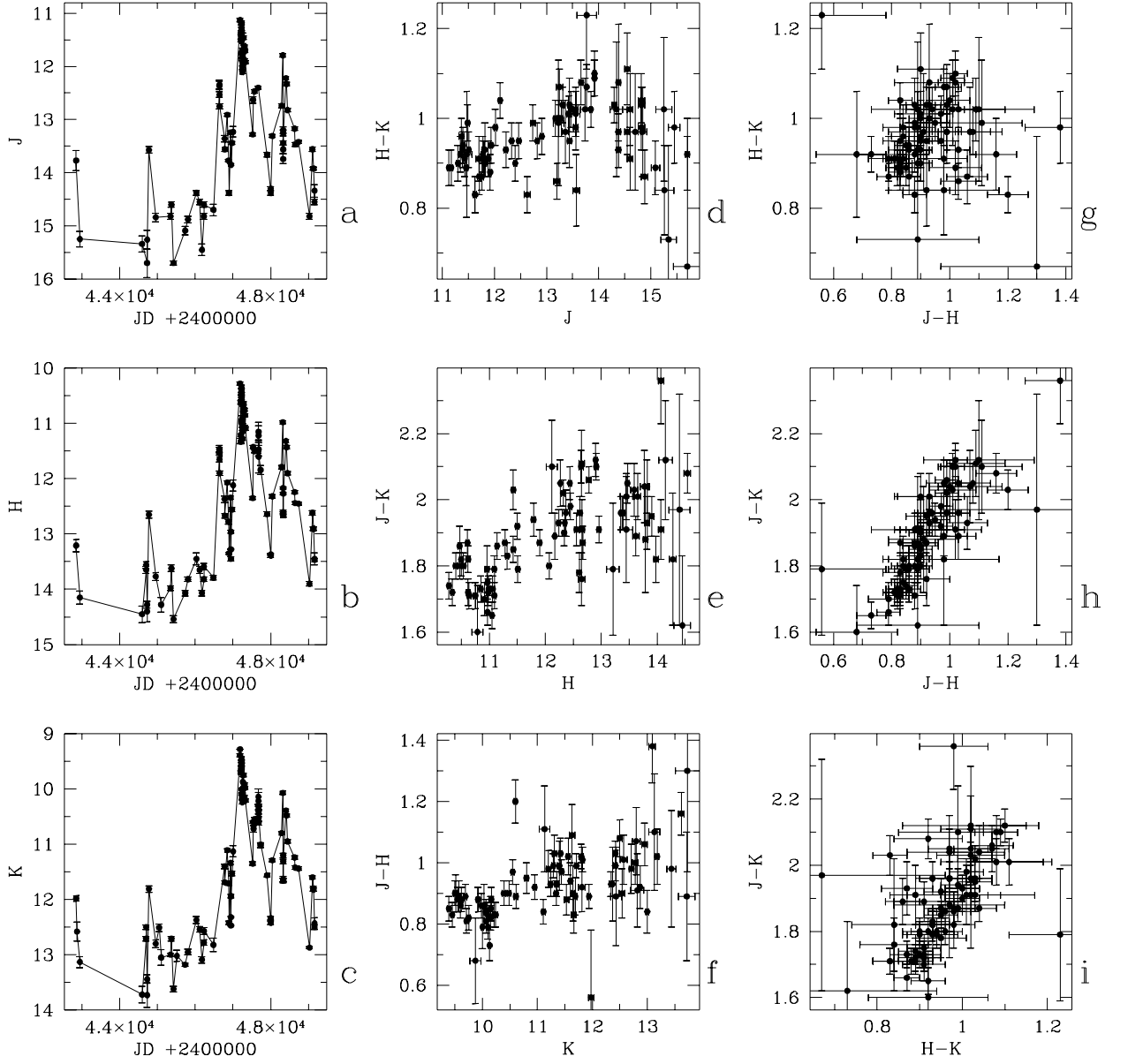


Fig. 9.— Light curves and color index properties for 1253-055

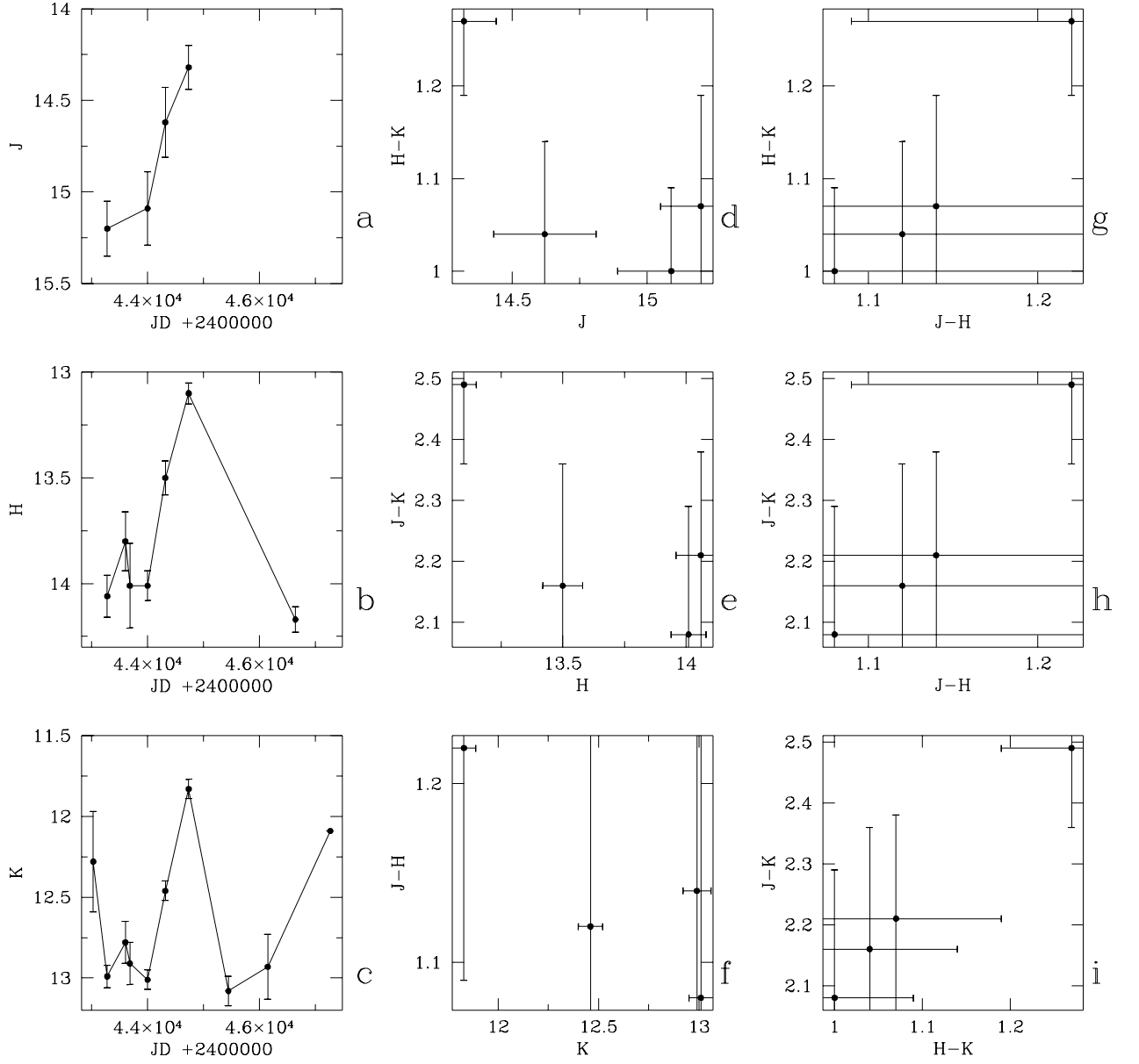


Fig. 10.— Light curves and color index properties for 1510-089

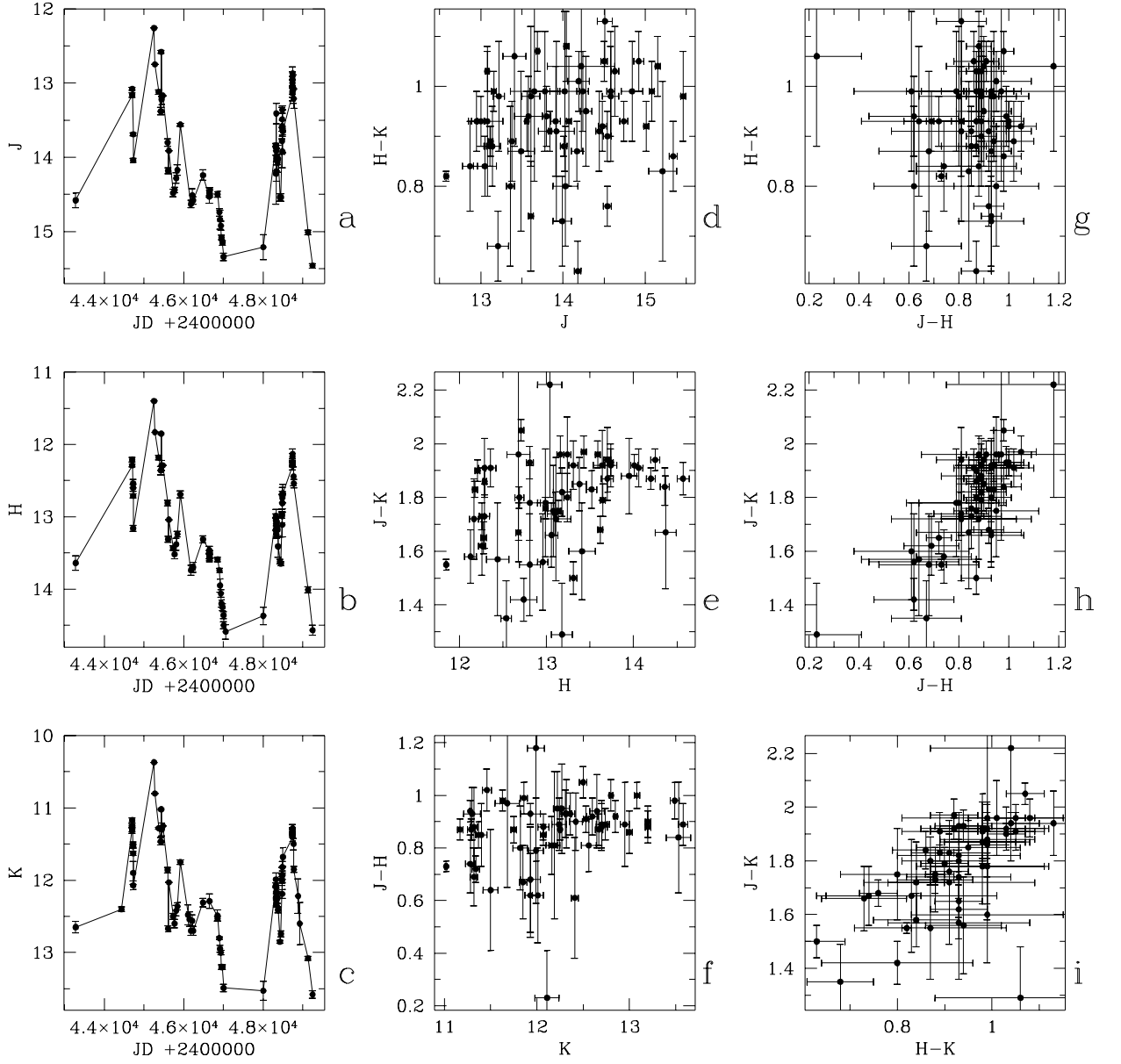


Fig. 11.— Light curves and color index properties for 1641+395

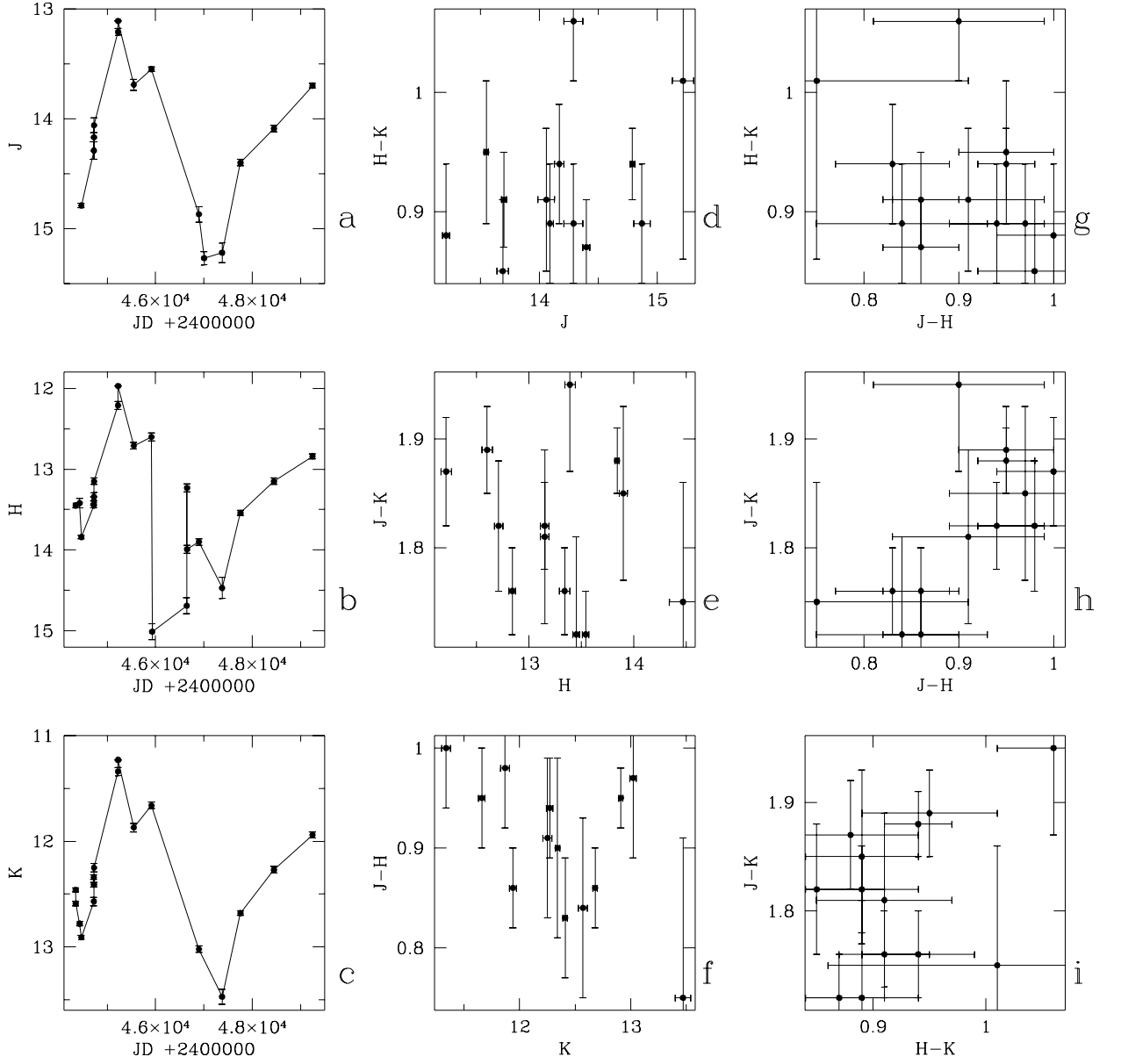


Fig. 12.— Light curves and color index properties for 1921-293

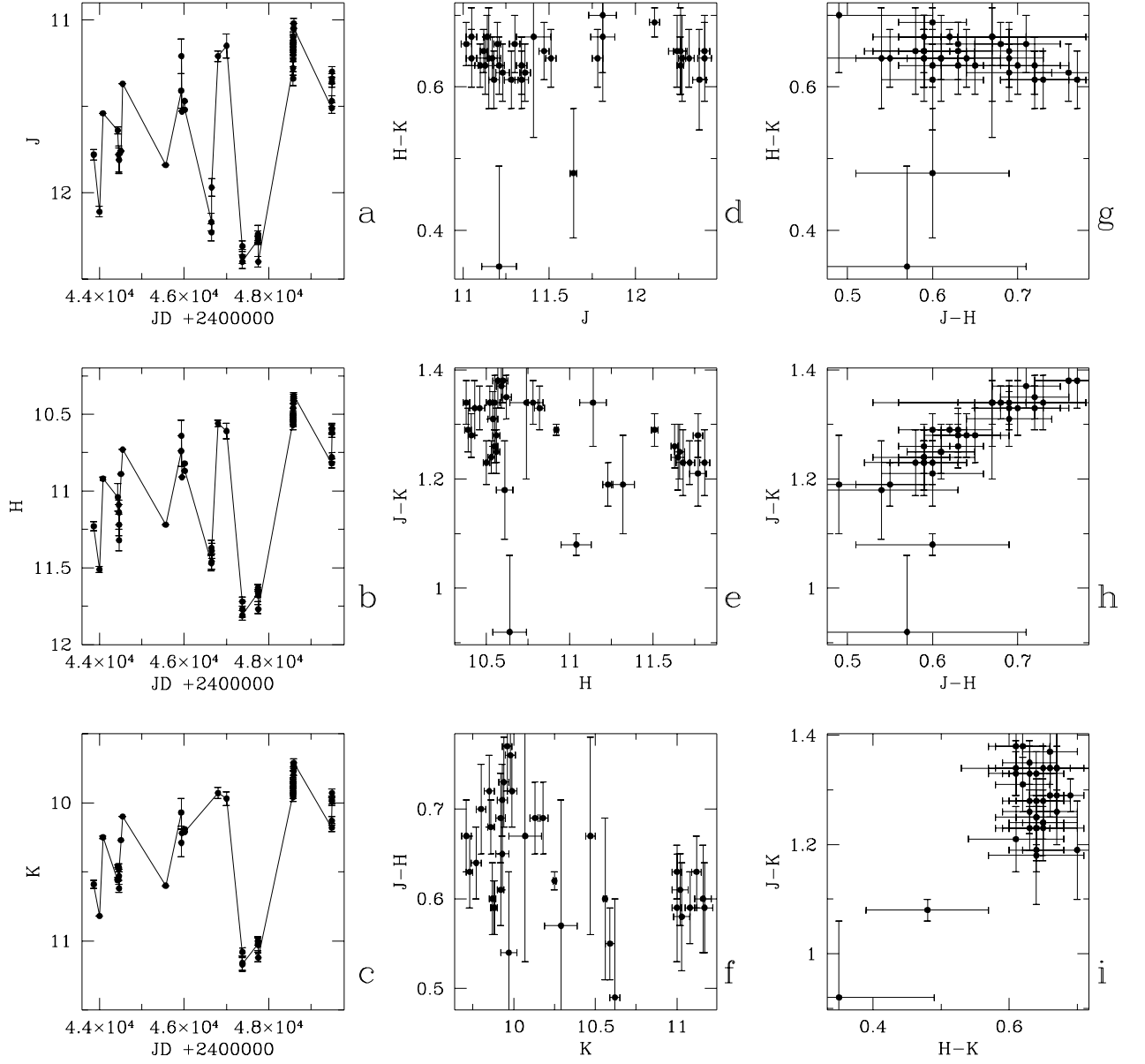


Fig. 13.— Light curves and color index properties for 2155-304



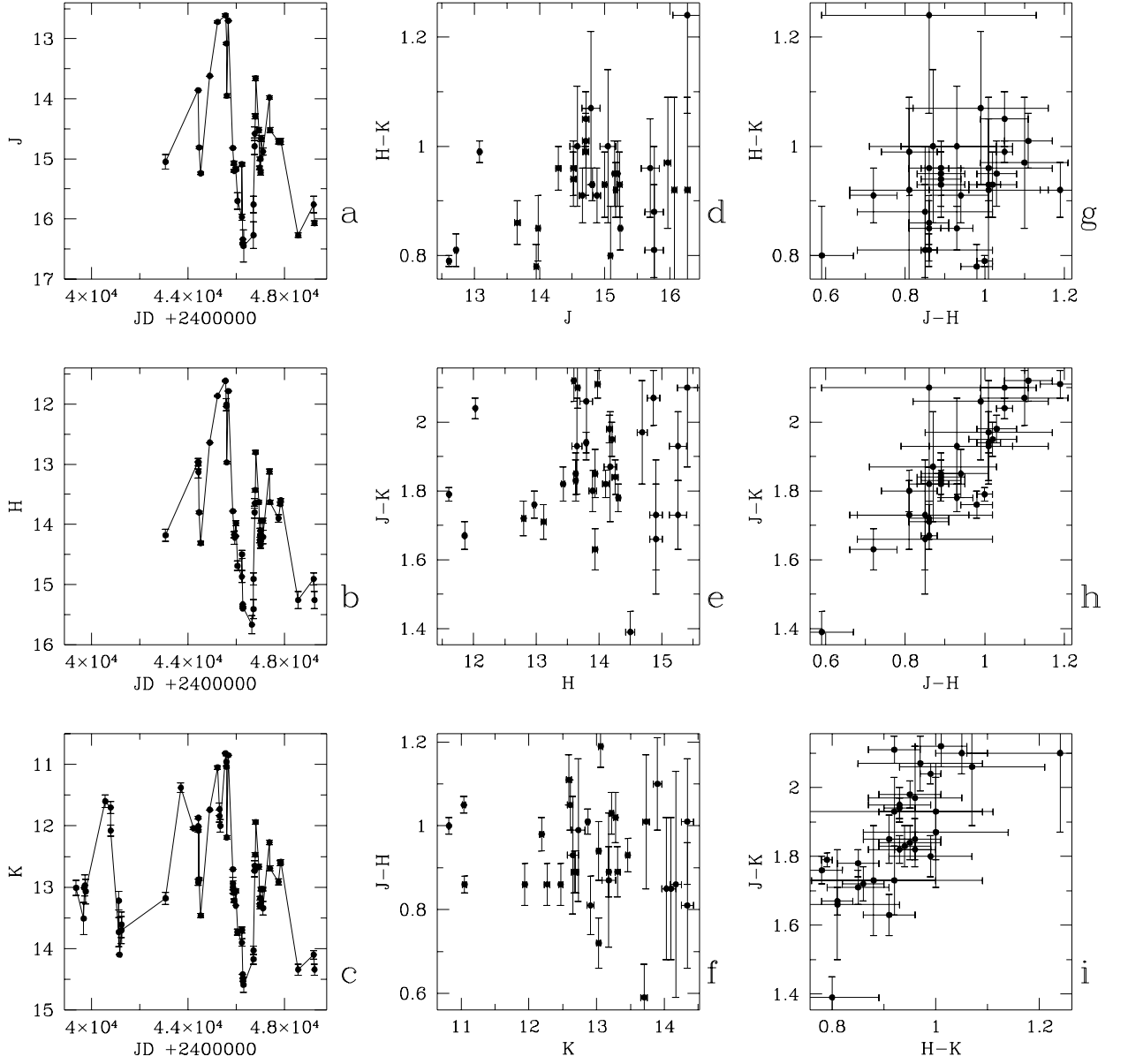


Fig. 14.— Light curves and color index properties for 2223-052

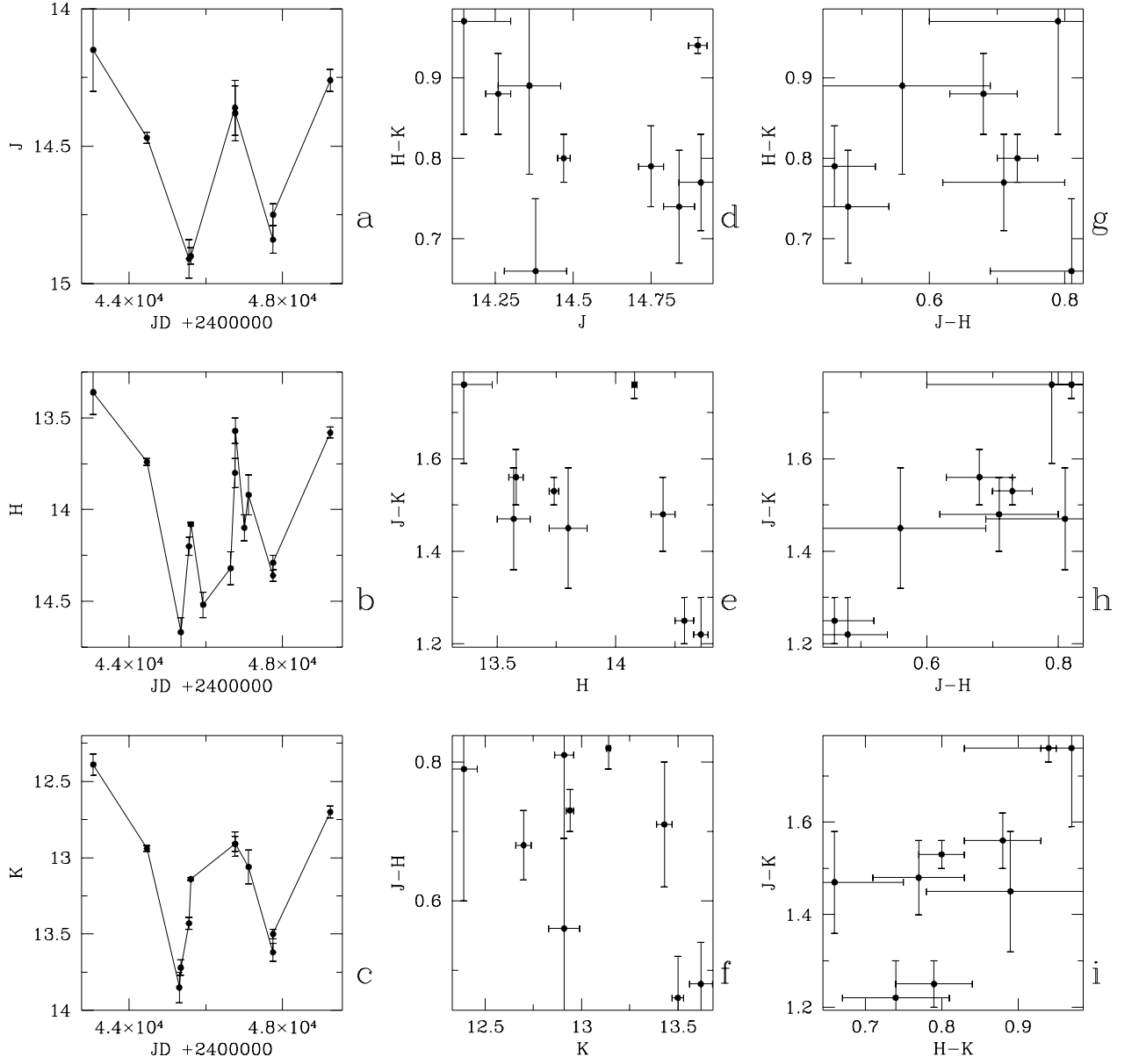


Fig. 15.— Light curves and color index properties for 2251+158

# Infrared Variation of Blazars

J. H. Fan

Center for Astrophysics, Guangzhou Normal University, Guangzhou 510400, China, e-mail:

[jhfan@guangztc.edu.cn](mailto:jhfan@guangztc.edu.cn)

Table 1. Near-Infrared Observations of 30 Blazars.

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
0109+224	43848.50					11.86	0.04
0109+224	44406.50			14.37	0.03	13.44	0.03
0109+224	44436.50	15.14	0.03	14.24	0.03	13.31	0.03
0109+224	46386.50	13.93	0.09	13.57	0.10	12.44	0.08
0109+224	46389.50	14.25	0.10	13.67	0.10	12.91	0.08
0109+224	46438.50	14.61	0.26	13.34	0.09	12.49	0.08
0109+224	46439.50	13.83	0.11	13.40	0.09	12.47	0.07
0109+224	46440.50	14.54	0.17	13.68	0.08	12.81	0.06
0109+224	46441.50	14.84	0.08	13.97	0.07	13.07	0.06
0109+224	46763.50	13.88	0.06	13.09	0.03	12.39	0.05
0109+224	46767.50	13.59	0.05	12.81	0.03	12.14	0.03
0109+224	46767.50	13.92	0.05	13.01	0.05	12.15	0.04
0109+224	47113.50	14.20	0.09	13.32	0.05	12.39	0.07
0109+224	47115.50			13.28	0.08	12.33	0.07
0109+224	47376.50	14.28	0.04	13.36	0.03	12.56	0.04
0109+244	46644.50			12.95	0.05		
0109+244	46647.50			12.96	0.04		
0109+244	46648.50			12.97	0.05		
0109+244	46649.50			13.03	0.05		
0109+244	46650.50	13.83	0.05	13.03	0.05		
0109+244	47004.50			13.37	0.05		
0109+244	47007.50			13.36	0.05		
0109+244	47058.50			12.93	0.10		
0109+244	47060.50			13.23	0.10		
0215+015	44436.50	13.27	0.02	12.44	0.02	11.64	0.02
0215+015	45345.50	13.90	0.03	12.99	0.02	12.14	0.03
0215+015	45347.50	13.80	0.02	12.98	0.02	12.14	0.03

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
0215+015	45930.50	11.90	0.10	11.13	0.10	10.47	0.10
0215+015	45931.50			11.23	0.10		
0215+015	45933.50	12.47	0.10	11.23	0.10		
0215+015	45934.50			11.23	0.10		
0215+015	46766.50			13.82	0.07	12.90	0.08
0215+015	47116.50					12.99	0.10
0301-243	44467.50	14.18	0.02	13.41	0.02	12.67	0.02
0301-243	47749.30	14.47	0.05	13.67	0.05	12.97	0.06
0301-243	47750.50					12.90	
0323+022	44933.50	14.36	0.04	13.69	0.04	13.16	0.04
0323+022	46439.50					13.32	0.12
0323+022	46644.50			14.24	0.07		
0323+022	47170.10	14.57	0.05	13.92	0.06	13.32	0.04
0323+022	47749.40	14.63	0.09	13.81	0.06	13.46	0.06
0323+022	47750.50					13.40	
0323+022	47751.40	14.87	0.04	14.33	0.05	14.29	0.13
0336-019	44594.50	15.45	0.25	15.00	0.20	14.57	0.15
0336-019	44951.50			15.90	0.20	14.97	0.22
0336-019	44955.50			15.96	0.12	14.99	0.25
0336-019	46648.50			15.28	0.19		
0406+121	43747.50					13.84	0.22
0406+121	43749.50			15.25	0.13	14.18	0.13
0406+121	43763.50			16.00	0.36	14.30	0.18
0406+121	43915.50	17.38	0.45	15.87	0.20	14.88	0.13
0406+121	43941.50					15.62	
0406+121	44467.50	17.28	0.05	16.15	0.05	15.17	0.05
0420-014	45398.50	14.16	0.03	13.32	0.05	12.37	0.03

Table 1—Continued

Name	JD 2400000+	J	$\Delta$ J	H	$\Delta$ H	K	$\Delta$ K
0420-014	45736.50	16.03	0.07	15.48	0.09	14.41	0.04
0420-014	45934.50			14.07	0.09		
0420-014	46764.50	13.57	0.06	12.60	0.03	11.80	0.04
0420-014	49311.50	15.18	0.03	14.26	0.05	13.64	0.05
0422+004	44559.50	14.28	0.02	13.36	0.02	12.45	0.02
0422+004	44590.50	13.38	0.31	12.84	0.11	12.04	0.08
0422+004	44591.50					12.24	0.10
0422+004	44592.50	14.03	0.10	13.16	0.10	12.26	0.10
0422+004	44652.50	13.85	0.10	13.09	0.10	12.21	0.10
0422+004	44951.50	14.50	0.10	13.80	0.07	12.99	0.08
0422+004	44955.50	14.09	0.70	13.20	0.07	12.30	0.07
0422+004	45343.50	13.14	0.03	12.30	0.02	11.49	0.03
0422+004	45347.50	13.49	0.04	12.64	0.03	11.79	0.02
0422+004	45758.50			15.35	0.07	14.58	0.05
0422+004	46112.50	12.81	0.03	12.00	0.06	11.15	0.03
0422+004	46377.56	13.91	0.16	13.00	0.06	12.21	0.09
0422+004	46474.36	13.50	0.07	12.56	0.05	11.71	0.04
0422+004	46766.47	13.79	0.04	12.88	0.04	12.11	0.05
0422+004	46767.46	13.92	0.07	13.04	0.06	11.97	0.06
0422+004	46769.48	13.44	0.09	12.57	0.03	11.72	0.03
0422+004	46770.48	13.50	0.06	12.49	0.04	11.61	0.04
0422+004	46804.10	13.42	0.08	12.53	0.02	11.64	0.02
0422+004	47150.37	13.64	0.08	12.82	0.07	11.99	0.06
0422+004	47170.2	13.19	0.05	12.37	0.08	11.52	0.03
0422+004	47171.1	13.18	0.05	12.36	0.02	11.52	0.05
0422+004	47172.1	13.11	0.08	12.28	0.07	11.41	0.04
0422+004	47208.50			12.89	0.04		

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
0422+004	47210.50			12.85	0.16	12.00	0.11
0422+004	47377.4	14.05	0.04	13.23	0.04	12.33	0.04
0422+004	47378.4	14.01	0.03	13.22	0.04	12.29	0.04
0422+004	47571.0	13.50	0.13	12.65	0.13	11.79	0.11
0422+004	48558.58	13.63	0.26	12.84	0.12	12.04	0.07
0422+004	48607.41	13.47	0.07	12.69	0.03	11.91	0.03
0422+004	48642.57	13.77	0.15	13.13	0.14	12.28	0.10
0422+004	48882.80	13.17	0.15	12.57	0.08	11.84	0.06
0422+004	48884.78	13.17	0.12	12.46	0.05	11.71	0.05
0422+004	48928.55	13.11	0.04	12.27	0.04	11.57	0.03
0422+004	48931.65	13.22	0.21	12.17	0.05	11.42	0.05
0521-365	41925.00					10.60	0.20
0521-365	41961.00			12.10	0.30	10.80	0.20
0521-365	43021.00			11.75	0.09	11.02	0.08
0521-365	43148.00					10.67	0.15
0521-365	43425.00	12.50	0.17	12.05	0.10	11.43	0.11
0521-365	43523.00	13.00	0.09	12.05	0.06	11.52	0.08
0521-365	43602.00	13.00	0.09	12.05	0.06	11.30	0.14
0521-365	43883.00	12.98	0.04	12.09	0.03	11.30	0.03
0521-365	44083.00	12.84	0.04	12.00	0.02	11.32	0.03
0521-365	44172.00	12.84	0.04	12.12	0.04	11.47	0.01
0521-365	44203.00	12.88	0.05	12.15	0.02	11.47	0.03
0521-365	44275.00	12.98		12.16		11.48	
0521-365	44453.00	13.07		12.39		11.54	
0521-365	44467.50	13.07	0.02	12.22	0.02	11.54	0.02
0521-365	44495.00	13.24		12.06		11.85	
0521-365	45931.50			12.64	0.10		

Table 1—Continued

Name	JD 2400000+	J	$\Delta$ J	H	$\Delta$ H	K	$\Delta$ K
0521-365	46803.2	12.89	0.02	12.10	0.04	11.41	0.04
0521-365	47168.2	12.80	0.06	12.03	0.01	11.34	0.05
0521-365	47378.4	12.81	0.06	12.08	0.03	11.41	0.03
0548-322	43435.00					12.17	0.13
0548-322	43602.00	13.56	0.09	12.81	0.06	12.28	0.05
0548-322	43888.00	13.60	0.06	13.05	0.06	12.44	0.06
0548-322	44175.00	13.65	0.06	12.86	0.05	12.53	0.06
0548-322	44203.00	13.56	0.12	12.89	0.03	12.35	0.05
0548-322	44274.00	13.76		13.05		12.54	
0548-322	44453.00	13.91	0.02	13.13	0.02	12.67	0.02
0548-322	44505.00	13.96		13.07		12.72	
0548-322	45327.50			12.99	0.11		
0548-322	46804.3	13.75	0.04	13.01	0.03	12.56	0.02
0548-322	47170.2	13.63	0.11	12.94	0.03	12.47	0.04
0716+332	46505.50	12.93	0.03	12.18	0.05	11.37	0.04
0716+332	46506.50	12.86	0.04	12.10	0.03	11.30	0.02
0716+332	46763.50			14.15	0.08	13.08	0.08
0716+332	46849.50	14.92	0.14	14.09	0.10	13.31	0.09
0736+017	44592.50	15.22	0.15	14.24	0.15	13.65	0.13
0736+017	44951.50	14.61	0.10	13.95	0.10	13.04	0.07
0736+017	44955.50	14.38	0.08	13.56	0.06	12.60	0.06
0736+017	45311.50					13.97	0.10
0736+017	45345.50	14.19	0.03	13.32	0.02	12.43	0.02
0736+017	45399.50	14.55	0.05	13.53	0.09	12.51	0.07
0736+017	45733.50	14.46	0.04	13.53	0.03	12.67	0.02
0736+017	45810.50	14.09	0.03	13.21	0.04	12.22	0.03
0736+017	46033.50	13.73	0.04	12.68	0.10	11.68	0.03



Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
0736+017	46037.50	14.33	0.17	13.14	0.10	11.98	0.08
0736+017	46481.50	14.30	0.04	13.44	0.05	12.43	0.05
0736+017	47207.50	14.66	0.03				
0736+017	47208.50	14.68	0.05				
0736+017	48176.50					12.63	0.04
0736+017	49311.50	13.00	0.03	12.21	0.03	11.32	0.03
0823-22	44559.50	13.90	0.02	13.04	0.02	12.20	0.02
0823-22	44594.50	15.30	0.15	14.84	0.20	14.16	0.11
0823-22	44951.50	13.91	0.08	13.24	0.06	12.79	0.08
0823-22	44955.50	13.92	0.07	13.12	0.06	12.51	0.07
0823-22	47168.50					12.00	
0823-22	47169.3	13.42	0.09	12.68	0.05	11.92	0.07
0823-22	47570.2	13.92	0.08	13.21	0.04	12.36	0.05
0912+297	44351.50			13.82	0.04	12.65	0.02
0912+297	44701.50					12.22	0.03
0912+297	44702.50	14.00	0.06	13.39	0.08	12.48	0.05
0912+297	44703.50	14.06	0.03	13.25	0.07	12.40	0.03
0912+297	45347.50	13.66	0.04	12.96	0.02	12.26	0.03
0912+297	45758.50			15.33	0.05	14.65	0.02
1034-293	44559.50	14.66	0.02	13.69	0.02	12.71	0.02
1034-293	44594.50	14.62	0.13	13.61	0.10		
1034-293	44654.50	14.56	0.10	13.61	0.10	12.49	0.10
1034-293	44771.50	14.44	0.15	13.45	0.13	12.36	0.10
1034-293	44951.50	15.02	0.14	13.92	0.07	13.31	0.11
1055+018	44951.50	15.10	0.11	14.44	0.08	13.28	0.10
1055+018	47571.34	14.99	0.37	14.00	0.41	13.15	0.36
1156+295	44699.50			11.09	0.02	10.22	0.02

Table 1—Continued

Name	JD 2400000+	J	$\Delta$ J	H	$\Delta$ H	K	$\Delta$ K
1156+295	44700.50	11.30	0.03			9.87	0.02
1156+295	44701.50	12.14	0.03	11.35	0.02	10.53	0.02
1156+295	44702.50	11.98	0.03	11.16	0.02	10.31	0.02
1156+295	44703.50	12.26	0.03	11.49	0.02	10.76	0.02
1156+295	44706.50	12.46	0.08	11.67	0.08	10.84	0.08
1156+295	44725.50	14.05	0.04	13.07	0.03	12.21	0.03
1156+295	44727.50	13.60	0.03	12.69	0.03	11.86	0.03
1156+295	44728.50	13.45	0.03	12.46	0.03	11.66	0.04
1156+295	44729.50	13.95	0.04	12.98	0.03	12.09	0.02
1156+295	45054.50	13.32	0.03	12.46	0.01	11.52	0.03
1156+295	45090.50	12.39	0.07	11.69	0.07	10.84	0.06
1156+295	45091.50	12.85	0.09	12.01	0.09	11.02	0.09
1156+295	45310.50					12.06	0.10
1156+295	45311.50					11.88	0.10
1156+295	45336.50					13.54	0.10
1156+295	45344.50	14.82	0.06	13.98	0.04	13.12	0.03
1156+295	45443.50	15.77	0.07	14.83	0.08	13.78	0.07
1156+295	45860.50	12.30	0.10	11.45	0.10	10.56	0.10
1156+295	45861.50	12.37	0.10	11.32	0.10	10.53	0.10
1156+295	45862.50	12.44	0.10	11.55	0.10	10.61	0.10
1156+295	45863.50	12.23	0.10	11.34	0.10	10.45	0.10
1156+295	45865.50	12.11	0.10	11.27	0.10	10.38	0.10
1156+295	45866.50	11.92	0.10	11.05	0.10	10.10	0.10
1156+295	46112.50	12.59	0.03	11.85	0.02	10.80	0.03
1156+295	46210.50	12.06	0.04	11.24	0.02	10.37	0.02
1156+295	46884.50	15.35	0.03	14.65	0.08	13.64	0.05
1156+295	46936.50	15.70	0.04	14.91	0.10	13.90	0.24

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1156+295	46950.50	15.61	0.04	14.79	0.04	13.79	0.05
1156+295	46974.50	15.48	0.03	14.63	0.03	13.64	0.05
1156+295	47207.50			14.15	0.06		
1156+295	47208.50			14.09	0.09		
1156+295	47209.50			14.14	0.05		
1156+295	47215.50	15.15	0.08	14.44	0.06	13.31	0.04
1156+295	47258.50	15.07	0.04	14.16	0.05	13.35	0.04
1156+295	49311.50	13.27	0.03	12.58	0.03	11.80	0.04
1218+304	43979.50	14.12	0.08	13.54	0.08	12.90	0.05
1218+304	44682.50					12.84	0.09
1218+304	44735.50			14.37	0.16	13.67	0.25
1218+304	46112.50	14.55	0.19	13.78	0.12	12.76	0.09
1244-255	44773.50	15.47	0.13	14.95	0.11	13.90	0.13
1244-255	44955.50	15.52	0.12	14.44	0.08	13.99	0.10
1244-255	47573.34	15.11	0.10	14.14	0.05	13.12	0.06
1253-055	42793.50	12.19	0.08	11.67	0.08	10.87	0.12
1253-055	42847.50	13.93	0.18	13.31	0.11	12.00	0.05
1253-055	42869.50					12.58	0.17
1253-055	42900.50					12.39	0.20
1253-055	42934.50			13.07	0.20	12.37	0.37
1253-055	42945.50	15.25	0.15	14.15	0.12	13.13	0.10
1253-055	42957.50			13.05	0.11	12.19	0.12
1253-055	43225.50	12.45	0.12	11.57	0.08	10.63	0.05
1253-055	43285.50	13.44	0.24	12.09	0.15	11.11	0.06
1253-055	43316.50	13.29	0.11	12.97	0.14	11.85	0.11
1253-055	44594.50	15.34	0.15	14.45	0.15	13.72	0.15
1253-055	44701.50					12.71	0.04

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1253-055	44702.50			13.65	0.06		
1253-055	44703.50			13.56	0.06	12.50	0.04
1253-055	44728.50	15.70	0.27	14.40	0.19	13.73	0.22
1253-055	44729.50	15.26	0.18	14.28	0.06	13.44	0.08
1253-055	44773.50	13.57	0.60	12.65	0.06	11.81	0.06
1253-055	44955.50	14.84	0.08	13.77	0.07	12.80	0.07
1253-055	45346.50	14.82	0.06	13.98	0.04	13.00	0.03
1253-055	45370.50	14.60	0.05	13.62	0.06	12.71	0.04
1253-055	45424.50	15.70	0.04	14.54	0.06	13.62	0.05
1253-055	45515.50					13.02	0.10
1253-055	45735.50	15.09	0.08	14.07	0.05	13.18	0.03
1253-055	45810.50	14.88	0.06	13.82	0.04	12.95	0.05
1253-055	46033.50	14.38	0.04	13.44	0.11	12.37	0.06
1253-055	46119.50	14.55	0.05	13.65	0.06	12.53	0.05
1253-055	46180.50	15.46	0.11	14.07	0.05	13.09	0.06
1253-055	46229.50	14.82	0.06	13.82	0.04	12.78	0.05
1253-055	46231.50	14.60	0.05	13.59	0.06	12.57	0.06
1253-055	46484.50	14.70	0.11	13.78	0.04	12.82	0.12
1253-055	46644.50			11.57	0.05		
1253-055	46645.50	12.42	0.08	11.55	0.06		
1253-055	46647.50	12.40	0.08	11.63	0.03		
1253-055	46648.50	12.59	0.05	11.74	0.05		
1253-055	46649.50	12.81	0.05	11.99	0.04		
1253-055	46782.50	13.42	0.06	12.41	0.06	11.46	0.04
1253-055	46787.50	13.62	0.04	12.70	0.04	11.74	0.03
1253-055	46852.50	12.97	0.03	12.10	0.03	11.16	0.03
1253-055	46884.50	13.83	0.02	12.81	0.04	11.77	0.03

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1253-055	46896.50	14.44	0.04	13.38	0.02	12.47	0.03
1253-055	46936.50	13.30	0.03	12.37	0.03	11.39	0.03
1253-055	46947.50			13.28	0.01	12.32	0.01
1253-055	46948.50			13.45	0.04	12.47	0.01
1253-055	46950.50	13.90	0.02	13.00	0.03	11.99	0.03
1253-055	46975.50	13.50	0.03	12.59	0.04	11.58	0.04
1253-055	47005.50	13.29	0.10	12.21	0.10	11.21	0.10
1253-055	47190.50	11.19	0.03	10.32	0.03	9.44	0.03
1253-055	47191.50					9.28	
1253-055	47208.50			11.42	0.05		
1253-055	47209.50			11.43	0.02		
1253-055	47210.50			11.31	0.02		
1253-055	47215.50	11.57	0.03	10.65	0.03	9.75	0.03
1253-055	47221.50	11.48	0.03	10.65	0.03	9.77	0.03
1253-055	47224.50	11.22	0.03	10.38	0.03	9.50	0.03
1253-055	47226.50	11.36	0.03	10.43	0.03	9.55	0.03
1253-055	47229.50	11.54	0.03	10.64	0.03	9.67	0.03
1253-055	47230.50	11.45	0.04	10.54	0.03	9.63	0.03
1253-055	47231.50	11.42	0.05	10.50	0.03	9.56	0.03
1253-055	47232.50	11.26	0.03				
1253-055	47232.50	11.45	0.03	10.57	0.03	9.66	0.03
1253-055	47233.50	11.40	0.03	10.50	0.03	9.60	0.03
1253-055	47248.50	11.88	0.06	11.00	0.04	10.08	0.04
1253-055	47249.50	12.17	0.03	11.32	0.03	10.30	0.03
1253-055	47250.50	12.07	0.03	11.17	0.03	10.22	0.03
1253-055	47258.50	11.87	0.03	11.00	0.03	10.11	0.03
1253-055	47260.50	12.00	0.03	11.12	0.03	10.20	0.03

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1253-055	47278.50	11.51	0.03	10.68	0.03	9.81	0.03
1253-055	47293.50	11.68	0.03	10.79	0.03	9.97	0.03
1253-055	47302.50	11.93	0.03	11.09	0.03	10.20	0.03
1253-055	47308.50	11.68	0.03	10.78	0.03	9.97	0.03
1253-055	47317.50	11.77	0.03	10.89	0.03	10.04	0.03
1253-055	47333.50	11.97	0.03	11.13	0.03	10.26	0.03
1253-055	47523.50	13.34	0.03	12.38	0.03	11.40	0.03
1253-055	47536.50	12.63	0.06	11.43	0.03	10.60	0.02
1253-055	47549.50					10.72	0.06
1253-055	47573.50	12.53	0.03	11.53	0.03	10.60	0.03
1253-055	47669.50	12.43	0.03	11.52	0.03	10.83	0.03
1253-055	47674.50					10.14	
1253-055	47682.50					10.61	
1253-055	47905.50	13.72	0.04	12.68	0.04	11.62	0.03
1253-055	48004.50	14.44	0.04	13.43	0.03	12.47	0.03
1253-055	48005.50	14.36	0.04	13.41	0.02	12.39	0.03
1253-055	48043.50	13.37	0.03	12.35	0.03	11.35	0.03
1253-055	48292.50	12.80	0.04	11.82	0.03	10.85	0.03
1253-055	48322.50	11.85	0.03	11.02	0.03	10.13	0.03
1253-055	48329.50	13.20	0.06	12.17	0.02	11.31	0.04
1253-055	48330.50	13.74	0.09	12.65	0.05	11.63	0.05
1253-055	48331.50	13.44	0.04	12.61	0.04	11.66	0.04
1253-055	48333.50	13.56	0.08	12.66	0.04	11.65	0.03
1253-055	48335.50	13.25	0.06	12.27	0.02	11.20	0.04
1253-055	48403.50	12.28	0.03	11.36	0.03	10.45	0.03
1253-055	48424.50	12.39	0.03	11.46	0.03	10.54	0.03
1253-055	48447.50	12.88	0.03	11.93	0.03	11.01	0.03

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1253-055	48636.50	13.23	0.03	12.27	0.03	11.30	0.03
1253-055	48651.50	13.53	0.04	12.47	0.03	11.48	0.03
1253-055	48741.50	13.48	0.03	12.48	0.03	11.49	0.03
1253-055	49029.50	14.88	0.06	13.94	0.04	12.93	0.02
1253-055	49105.50	13.62	0.04	12.65	0.04	11.66	0.03
1253-055	49133.50	13.98	0.03	12.93	0.03	11.86	0.04
1253-055	49134.50	13.98	0.03	12.95	0.03	11.88	0.03
1253-055	49162.50	14.61	0.05	13.51	0.03	12.56	0.04
1253-055	49163.50	14.40	0.12	13.48	0.11	12.49	0.10
1510-089	43029.00					12.29	0.31
1510-089	43279.50	15.23	0.15	14.08	0.10	13.00	0.07
1510-089	43602.00			13.82	0.14	12.79	0.13
1510-089	43683.00			14.03	0.20	12.92	0.13
1510-089	4400	15.12	0.20	14.03	0.07	13.02	0.06
1510-089	44317.00	14.65	0.19	13.52	0.08	12.47	0.06
1510-089	44734.50	14.35	0.12	13.12	0.05	11.84	0.06
1510-089	45443.50					13.09	0.09
1510-089	46149.50					12.94	0.20
1510-089	46644.50			14.19	0.06		
1510-089	47266.50					12.10	
1641+399	43279.50	14.60	0.10	13.65	0.10	12.66	0.08
1641+399	44431.50					12.41	0.03
1641+399	44700.50					11.32	0.04
1641+399	44701.50					11.26	0.03
1641+399	44702.50	13.18	0.03	12.30	0.02	11.30	0.04
1641+399	44703.50	13.10	0.02	12.22	0.03	11.18	0.03
1641+399	44725.50			12.55	0.06	11.52	0.04

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1641+399	44726.50			12.61	0.05	11.54	0.03
1641+399	44727.50	13.71	0.02	12.72	0.03	11.64	0.03
1641+399	44728.50					11.91	0.16
1641+399	44729.50	14.06	0.03	13.17	0.04	12.08	0.06
1641+399	45252.50	12.28		11.41		10.38	
1641+399	45274.50	12.77		11.84		10.81	
1641+399	45370.50	13.14	0.03	12.19	0.03	11.29	0.05
1641+399	45424.50	13.40	0.05	12.37	0.06	11.47	0.05
1641+399	45428.50	13.40		12.37		11.48	
1641+399	45433.50	12.60	0.02	11.86	0.01	11.03	0.01
1641+399	45443.50	13.24	0.07	12.30	0.07	11.31	0.09
1641+399	45447.50	13.20		12.31		11.30	
1641+399	45476.50	13.19		12.30		11.26	
1641+399	45595.50	13.82	0.05	12.82	0.04	11.87	0.04
1641+399	45607.50	14.20	0.04	13.32	0.04	12.68	0.04
1641+399	45626.50	13.93		13.05		12.04	
1641+399	45735.50	14.50	0.05	13.44	0.03	12.51	0.04
1641+399	45768.50	14.46	0.04	13.53	0.06	12.61	0.06
1641+399	45811.50	14.30	0.07	13.39	0.08	12.43	0.07
1641+399	45840.50	14.19	0.07	13.25	0.04	12.37	0.05
1641+399	45915.50	13.58	0.02	12.70	0.05	11.76	0.03
1641+399	46112.50					12.49	0.14
1641+399	46148.50					12.55	0.10
1641+399	46180.50	14.65	0.05	13.75	0.07	12.71	0.06
1641+399	46216.50	14.53	0.09	13.71	0.04	12.57	0.08
1641+399	46238.50	14.60	0.05	13.71	0.07	12.71	0.06
1641+399	46484.50	14.26	0.07	13.32	0.05	12.32	0.06



Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1641+399	46644.50	14.55	0.09	13.47	0.05		
1641+399	46645.50	14.49	0.06	13.53	0.06		
1641+399	46647.50	14.48	0.05	13.54	0.05		
1641+399	46648.50			13.53	0.05	12.30	0.10
1641+399	46649.50	14.51	0.05	13.58	0.05		
1641+399	46650.50			13.56	0.05		
1641+399	46850.50					12.50	0.08
1641+399	46852.50	14.52	0.04	13.60	0.03	12.54	0.03
1641+399	46896.50	14.76	0.05	13.75	0.03	12.81	0.02
1641+399	46917.50	14.86	0.13	13.96	0.09	12.96	0.05
1641+399	46936.50	14.94	0.06	14.07	0.05	13.01	0.03
1641+399	46950.50	15.10	0.03	14.21	0.05	13.21	0.03
1641+399	46974.50	15.17	0.03	14.26	0.05	13.21	0.03
1641+399	47005.50	15.36	0.05	14.37	0.05	13.50	0.05
1641+399	47007.50			14.51	0.05		
1641+399	47058.50			14.60	0.10		
1641+399	48005.50	15.23	0.17	14.38	0.12	13.54	0.13
1641+399	48322.50	13.86	0.02	13.00	0.03	12.08	0.03
1641+399	48326.50	14.24	0.41	13.05	0.14	12.00	0.09
1641+399	48329.50	13.93	0.06	13.11	0.09	12.17	0.06
1641+399	48330.50	13.43	0.14	13.19	0.12	12.12	0.13
1641+399	48331.50	14.21	0.13	13.25	0.04	12.23	0.04
1641+399	48333.50	14.01	0.11	13.07	0.07	12.33	0.05
1641+399	48335.50	14.05	0.15	13.09	0.09	12.28	0.08
1641+399	48342.50	14.03	0.04	13.15	0.02	12.26	0.01
1641+399	48366.50	14.09	0.03	13.19	0.10	12.25	0.08
1641+399	48375.50	14.04	0.18	13.42	0.15	12.42	0.04

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1641+399	48424.50	14.56	0.05	13.63	0.03	12.86	0.02
1641+399	48447.50	14.56	0.05	13.66	0.03	12.75	0.04
1641+399	48477.50	13.80	0.18	13.00	0.09	12.00	0.08
1641+399	48478.50	13.60	0.17	12.97	0.06	12.02	0.06
1641+399	48479.50	13.51	0.16	12.82	0.12	11.94	0.11
1641+399	48481.50	13.94	0.22	13.12	0.17	12.20	0.06
1641+399	48482.50	13.38	0.05	12.75	0.15	11.94	0.06
1641+399	48485.50	13.63	0.03	12.69	0.03	11.94	0.11
1641+399	48486.50	13.63	0.11	12.82	0.12	11.83	0.08
1641+399	48498.50	13.67	0.29	12.69	0.13	11.69	0.13
1641+399	48738.50	13.16	0.10	12.30	0.06	11.41	0.06
1641+399	48739.50	13.02	0.04	12.29	0.03	11.35	0.04
1641+399	48740.50	12.97	0.10	12.27	0.04	11.33	0.04
1641+399	48741.50	13.07	0.14	12.18	0.05	11.33	0.04
1641+399	48741.50	13.13	0.04	12.27	0.03	11.38	0.03
1641+399	48743.50	12.89	0.09	12.14	0.07	11.29	0.05
1641+399	48769.50	13.10	0.19	12.45	0.13	11.51	0.08
1641+399	48771.50	13.23	0.13	12.55	0.06	11.86	0.04
1641+399	48881.50					12.23	0.24
1641+399	48922.50					12.61	0.29
1641+399	49133.50	15.03	0.03	14.02	0.04	13.09	0.03
1641+399	49246.50	15.48	0.03	14.58	0.07	13.59	0.05
1717+178	44467.50	15.14	0.02	14.22	0.02	13.24	0.02
1717+178	46649.50					14.24	0.05
1717+178	46650.50					14.43	0.05
1717+178	47007.50					15.21	0.20
1921-293	44350.50			13.53	0.03	12.50	0.02

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
1921-293	44351.50					12.63	0.02
1921-293	44430.50			13.50	0.06	12.82	0.02
1921-293	44467.50	14.92	0.02	13.92	0.02	12.95	0.02
1921-293	44725.50	14.42	0.08	13.53	0.03	12.61	0.04
1921-293	44726.50	14.42	0.08	13.47	0.05	12.38	0.02
1921-293	44727.50	14.30	0.04	13.42	0.05	12.45	0.02
1921-293	44729.50	14.19	0.07	13.23	0.04	12.29	0.04
1921-293	45224.50	13.34	0.03	12.29	0.05	11.38	0.04
1921-293	45226.50	13.24		12.05		11.27	
1921-293	45552.50	13.82	0.05	12.79	0.04	11.91	0.04
1921-293	45915.50	13.68	0.02	12.68	0.05	11.70	0.03
1921-293	45932.50			15.09	0.10		
1921-293	46646.50			14.77	0.10		
1921-293	46649.50			13.31	0.05		
1921-293	46650.50			14.07	0.05		
1921-293	46896.50	15.00	0.07	13.98	0.04	13.06	0.03
1921-293	47004.50	15.40	0.06				
1921-293	47377.05	15.35	0.09	14.55	0.13	13.51	0.07
1921-293	47753.15	14.53	0.03	13.62	0.03	12.72	0.02
1921-293	48447.50	14.22	0.03	13.23	0.04	12.31	0.03
1921-293	49246.50	13.83	0.02	12.92	0.03	11.98	0.03
2155-304	43863.00	11.78	0.03	11.23	0.03	10.59	0.03
2155-304	43999.00	12.11	0.03	11.51	0.02	10.82	
2155-304	44079.00	11.54		10.92	0.01	10.25	0.01
2155-304	44430.50	11.64	0.02	11.04	0.09	10.56	0.01
2155-304	44431.50					10.55	0.01
2155-304	44432.50					10.46	0.01

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
2155-304	44453.00	11.78		11.09		10.48	
2155-304	44461.50	11.81	0.08	11.32	0.07	10.62	0.03
2155-304	44462.50			11.22	0.07	10.53	0.03
2155-304	44463.50	11.81	0.07	11.14	0.08	10.47	0.03
2155-304	44505.00	11.76		10.89		10.27	
2155-304	44545.00	11.37		10.73		10.10	
2155-304	45564.50	11.84		11.22		10.60	
2155-304	45930.50	11.41	0.10	10.74	0.10	10.07	0.10
2155-304	45934.50	11.21	0.10	10.64	0.10	10.29	0.10
2155-304	45949.50	11.53		10.91		10.22	
2155-304	46013.50	11.47		10.82		10.19	
2155-304	46015.50	11.52		10.87		10.21	
2155-304	46644.50	12.17	0.05	11.47	0.05		
2155-304	46648.50	12.23	0.05	11.37	0.05		
2155-304	46649.50			11.46	0.05		
2155-304	46650.50	11.97	0.05	11.39	0.05		
2155-304	46803.04	11.21	0.03	10.56	0.02	9.93	0.04
2155-304	47004.50	11.15	0.07	10.61	0.05	9.97	0.05
2155-304	47376.26	12.31	0.03	11.72	0.03	11.08	0.03
2155-304	47377.3	12.37	0.04	11.77	0.05	11.16	0.05
2155-304	47378.14	12.40	0.04	11.81	0.03	11.17	0.05
2155-304	47748.11	12.27	0.02	11.66	0.03	11.02	0.05
2155-304	47749.15	12.26	0.02	11.63	0.02	11.00	0.03
2155-304	47750.16	12.24	0.05	11.65	0.04	11.00	0.03
2155-304	47751.09	12.26	0.04	11.68	0.04	11.03	0.05
2155-304	47753.16	12.40	0.03	11.77	0.03	11.12	0.03
2155-304	48575.50	11.28	0.04	10.55	0.03	9.94	0.03

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
2155-304	48576.50	11.17	0.03	10.56	0.02	9.92	0.02
2155-304	48576.50	11.34	0.04	10.57	0.03	9.96	0.03
2155-304	48577.50	11.12	0.02	10.53	0.02	9.88	0.02
2155-304	48577.50	11.18	0.03	10.46	0.03	9.85	0.03
2155-304	48579.50	11.10	0.03	10.50	0.02	9.87	0.02
2155-304	48579.50	11.23	0.04	10.54	0.03	9.92	0.03
2155-304	48580.50	11.20	0.02	10.52	0.02	9.86	0.02
2155-304	48581.50	11.14	0.02	10.55	0.02	9.88	0.02
2155-304	48585.50	11.13	0.04	10.43	0.03	9.80	0.03
2155-304	48590.50	11.05	0.03	10.41	0.02	9.77	0.03
2155-304	48591.50	11.02	0.03	10.39	0.02	9.73	0.02
2155-304	48592.50	11.05	0.03	10.38	0.02	9.71	0.03
2155-304	49491.50	11.51	0.03	10.82	0.03	10.18	0.03
2155-304	49492.50	11.47	0.03	10.78	0.03	10.13	0.03
2155-304	49496.50	11.36	0.03	10.60	0.03	9.98	0.03
2155-304	49497.50	11.34	0.03	10.62	0.03	9.99	0.03
2155-304	49498.50	11.30	0.03	10.59	0.03	9.93	0.03
2208-137	45934.50			14.54	0.07		
2208-137	46646.50			14.40	0.05		
2208-137	46647.50			14.43	0.05		
2208-137	46649.50			14.50	0.08		
2208-137	46650.50			14.75	0.07		
2208-137	47377.3	15.27	0.08	14.44	0.10	13.29	0.05
2208-137	47749.3	15.72	0.19	14.69	0.08	13.57	0.15
2223-052	39364.50					13.01	0.12
2223-052	39671.50					13.51	0.26
2223-052	39698.50					13.01	

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
2223-052	39729.50					12.97	0.17
2223-052	39760.50					13.07	0.20
2223-052	40571.50					11.60	0.10
2223-052	40795.50					11.70	0.10
2223-052	40795.50					12.08	0.09
2223-052	41133.50					13.73	0.24
2223-052	41134.50					13.22	0.15
2223-052	41159.50					14.10	
2223-052	41244.50					13.61	0.21
2223-052	41245.50					13.70	0.22
2223-052	43067.50	15.05	0.12	14.18	0.10	13.18	0.10
2223-052	43707.50					11.38	0.08
2223-052	44229.50					12.04	0.02
2223-052	44424.50	13.86		12.96		12.01	
2223-052	44430.50					11.87	0.02
2223-052	44431.50			12.99	0.09	12.92	0.05
2223-052	44432.50			13.13	0.10	12.08	0.02
2223-052	44467.50	14.81	0.02	13.80	0.02	12.87	0.02
2223-052	44528.50	15.24	0.02	14.31	0.03	13.46	0.03
2223-052	44904.50	13.62		12.64		11.74	
2223-052	45224.50	12.72	0.02	11.86	0.01	11.05	0.03
2223-052	45310.50					11.84	0.10
2223-052	45311.50					11.73	0.10
2223-052	45339.50					12.00	0.10
2223-052	45552.50	12.61	0.02	11.61	0.01	10.82	0.01
2223-052	45592.50			12.01	0.10	10.96	0.10
2223-052	45594.50	13.08	0.02	12.03	0.01	11.04	0.02

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
2223-052	45606.50	13.95	0.03	12.97	0.02	12.19	0.03
2223-052	45671.50	12.70		11.78		10.85	
2223-052	45860.50	14.82		13.78		12.71	
2223-052	45861.50					12.94	0.10
2223-052	45862.50					13.00	0.10
2223-052	45900.50	15.07	0.03			13.09	0.03
2223-052	45916.50	15.20	0.02	14.17	0.05	13.22	0.03
2223-052	45934.50			14.22	0.11		
2223-052	45981.50	15.18		14.20		13.30	
2223-052	45988.50	15.17	0.03	13.98	0.04	13.06	0.03
2223-052	46057.50	15.70	0.14	14.69	0.08	13.73	0.05
2223-052	46230.50	15.97	0.05	14.87	0.10	13.90	0.06
2223-052	46237.50	15.09	0.03	14.50	0.07	13.70	0.05
2223-052	46266.50	16.42		15.33		14.42	
2223-052	46272.50	16.40		15.40		14.53	
2223-052	46273.50	16.34		15.37		14.48	
2223-052	46302.50	16.45	0.27			14.59	0.12
2223-052	46647.50			15.67	0.15		
2223-052	46714.50	16.27	0.22	15.41	0.16	14.17	0.08
2223-052	46715.50	15.76	0.14	14.91	0.10	14.03	0.07
2223-052	46763.50	14.79	0.14	13.80	0.10	12.73	0.10
2223-052	46766.50	14.58	0.11	13.65	0.08	12.65	0.08
2223-052	46788.50	14.29	0.04	13.43	0.03	12.47	0.03
2223-052	46806.50	13.66	0.04	12.80	0.03	11.94	0.03
2223-052	46936.50	14.52	0.04	13.63	0.03	12.67	0.04
2223-052	46974.50	15.15	0.03	14.26	0.05	13.31	0.04
2223-052	46999.50	15.00	0.03	14.11	0.05	13.18	0.03

Table 1—Continued

Name	JD 2400000+	J	$\Delta J$	H	$\Delta H$	K	$\Delta K$
2223-052	47004.50	15.23	0.04	14.21	0.05	13.28	0.03
2223-052	47006.50			14.29	0.10		
2223-052	47007.50			14.34	0.06		
2223-052	47026.50	14.66	0.05	13.94	0.04	13.03	0.03
2223-052	47105.50	14.88	0.06	13.94	0.04	13.03	0.03
2223-052	47113.50			14.21	0.11	13.34	0.11
2223-052	47376.31	13.98	0.03	13.12	0.04	12.27	0.04
2223-052	47398.50	14.52	0.04	13.63	0.03	12.69	0.04
2223-052	47750.15	14.71	0.04	13.90	0.06	12.91	0.05
2223-052	47828.50	14.71	0.05	13.66	0.03	12.61	0.04
2223-052	47845.50	14.71	0.05	13.60	0.03	12.59	0.04
2223-052	48565.50	16.27	0.04	15.26	0.14	14.34	0.09
2223-052	49211.50	15.76	0.14	14.91	0.10	14.10	0.07
2223-052	49246.50	16.07	0.04	15.26	0.14	14.34	0.09
2251+158	43067.50	14.18	0.15	13.38	0.12	12.40	0.07
2251+158	44467.50	14.50	0.02	13.76	0.02	12.95	0.02
2251+158	45311.50					13.86	0.10
2251+158	45350.50			14.69	0.08	13.73	0.05
2251+158	45562.50	14.94	0.07	14.22	0.05	13.44	0.04
2251+158	45609.50	14.93	0.03	14.10	0.01	13.15	0.01
2251+158	45932.50			14.54	0.07		
2251+158	46648.50			14.34	0.09		
2251+158	46763.50	14.39	0.10	13.82	0.08	12.92	0.08
2251+158	46766.50	14.41	0.10	13.59	0.07	12.92	0.05
2251+158	47005.50			14.12	0.07		
2251+158	47115.50			13.94	0.11	13.07	0.11
2251+158	47752.23	14.87	0.05	14.38	0.03	13.63	0.06



Table 1—Continued

Name	JD 2400000+	J	$\Delta$ J	H	$\Delta$ H	K	$\Delta$ K
2251+158	47753.29	14.78	0.04	14.31	0.04	13.51	0.03
2251+158	49246.50	14.29	0.04	13.60	0.03	12.71	0.04
2345-167	45925.50			15.85	0.10		
2345-167	47377.33	16.59	0.18	15.71	0.12	14.66	0.17